AD-A202 030

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

COMPUTER-BASED TRAINING APPLIED TO THE
U. S. NAVY MAINTENANCE TRAINING
IMPROVEMENT PROGRAM

by

Galen Jay Ledeboer

September 1988

Thesis Advisor: John B. Isett

Approved for public release; distribution is unlimited

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED

1b RESTRICTIVE MARKINGS:

2a SECURITY CLASSIFICATION AUTHORITY:

2b DECLASSIFICATION / DOWNGRADING SCHEDULE:

3 DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited

4 PERFORMING ORGANIZATION REPORT NUMBER(S):

5 MONITORING ORGANIZATION REPORT NUMBER(S):

6a NAME OF PERFORMING ORGANIZATION: Naval Postgraduate School

6b OFFICE SYMBOL (If applicable): Code 54IS

7a NAME OF MONITORING ORGANIZATION: Naval Postgraduate School

6c ADDRESS (City, State, and ZIP Code): Monterey, CA 93943-5000

7b ADDRESS (City, State, and ZIP Code): Monterey, CA 93943-5000

8a NAME OF FUNDING / SPONSORING ORGANIZATION:

8b OFFICE SYMBOL (If applicable):

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

8c ADDRESS (City, State, and ZIP Code):

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO.

11 TITLE (Include Security Classification): COMPUTER-BASED TRAINING APPLIED TO THE U.S. NAVY MAINTENANCE TRAINING IMPROVEMENT PROGRAM

12 PERSONAL AUTHOR(S): Ledeboer, Galen J.

13a TYPE OF REPORT: Master's Thesis

13b TIME COVERED: FROM ____ TO ____

14 DATE OF REPORT (Year, Month, Day): September 1988

15 PAGE COUNT: 131

16 SUPPLEMENTARY NOTATION: The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government

17 COSATI CODES

FIELD	GROUP	SUB-GROUP

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number): Theses.
COMPUTER-BASED TRAINING
MAINTENANCE TRAINING IMPROVEMENT PROGRAM
EXPERT SYSTEMS, MILITARY TRAINING

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

In the military, there has been much interest in combining instructional methodologies with computer technology to facilitate training. The potential for life cycle cost reduction while improving the effectiveness of training is very attractive. Thus, Computer-Based Training (CBT) has been embraced by the U.S. Navy. Initially, CBT was used primarily to manage training programs and has more recently also been used to provide instruction directly. However, CBT has not adequately kept pace with the formidable record-keeping and data requirements of a typical Navy training program. Proposals are introduced here to improve data processing and management for CBT. Also, concepts are described to promote better decision-making so that more efficient use can be made of CBT resources, both now and in the future. Methods to facilitate actual training with CBT are discussed. These initiatives are applied specifically to the Navy Maintenance Training Improvement Program (MTIP).

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION: Unclassified

22a NAME OF RESPONSIBLE INDIVIDUAL: John B. Isett

22b TELEPHONE (Include Area Code): (408) 646-2464

22c OFFICE SYMBOL: Code 54IS

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE

☆ U.S. Government Printing Office: 1986—606-24.

Unclassified

Approved for public release, distribution unlimited

Computer-Based Training Applied to the U. S. Navy Maintenance Training Improvement Program

by

Galen Jay Ledeboer
Lieutenant Commander, United States Navy
A.B., Dordt College, 1973

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN INFORMATION SYSTEMS

from the

NAVAL POSTGRADUATE SCHOOL
September 1988

Author: Galen Jay Ledeboer
Galen Jay Ledeboer

Approved by:
John B. Isett, Thesis Advisor

Gerald L. Pauler, Second Reader

David R. Whipple, Jr., Chairman
Department of Administrative Sciences

Kneale T. Marshall
Kneale T. Marshall
Dean of Information and Policy Sciences

ABSTRACT

In the military, there has been much interest in combining instructional methodologies with computer technology to facilitate training. The potential for life cycle cost reduction while improving the effectiveness of training is very attractive. Thus, Computer-Based Training (CBT) has been embraced by the U. S. Navy. Initially, CBT was used primarily to manage training programs and has more recently also been used to provide instruction directly. However, CBT has not adequately kept pace with the formidable record-keeping and data requirements of a typical Navy training program. Proposals are introduced here to improve data processing and management for CBT. Also, concepts are described to promote better decision-making so that more efficient use can be made of CBT resources, both now and in the future. Methods to facilitate actual training with CBT are discussed. These initiatives are applied specifically to the Navy Maintenance Training Improvement Program (MTIP).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

Thanks to Dr. John Isett for his guidance and encouragement. His Decision Support Systems class also provided the impetus for several of the ideas and references found in this thesis.

Thanks to Dr. Gerald Pauler for his critical evaluation and very constructive suggestions.

Thanks to Daniel and David for sharing their Daddy.

Finally, thanks to my wife, Peggy, for her typing, editing, comments and especially her long-suffering during the whole process.

I. INTRODUCTION

A. COMPUTER-BASED TRAINING

In recent decades, there has been significant interest in using individualized instruction and computer technology to facilitate training. The potential cost reduction and learning efficiency advantages seemed readily apparent. Hence, much research and development has been directed to that area (see Appendix C). A widely used methodology for conducting training has evolved. The term to be used here for that activity is Computer-Based Training (CBT). CBT is comprised of two major subsystems, Computer-Managed Instruction (CMI) and Computer-Aided Instruction (CAI). [O'Neil 81:p. 1] CAI is also frequently referred to as Computer-Aided Learning (CAL). CBT, or Computer-Based Instruction (CBI) as it is frequently known, is primarily comprised of and loosely defined as the sum of these two components.

CBT, CMI and CAI are selected from a proliferation of terminology which has developed over the years. Appendix A provides definitions of most associated terms found in current literature. Appendix B lists many CBT and U. S. Navy-related acronyms.

CBT development typically begins with the CMI component. CMI is defined as a subsystem of CBT which uses the computer to manage overall instructional activity. This includes planning, administration, monitoring student progress, allocating instructional resources and providing reports. CMI is the function which regulates the level of control and efficiency in the training system. Figure 1.1 illustrates some basic components of a typical training center as they are related to a basic CMI subsystem. Notice that CMI accommodates both non-computerized and computerized instruction.

CAI, the other major subsystem of CBT, is defined as a method of learning where a computer is the primary storage and delivery device for instruction, like a tutor. The student interacts directly with a computer in an individualized training environment. The student works in real time and may receive direct feedback from the computer. [NPRDC TN 82-17, 82:p. 2; Burke 82:p. 187]

CMI and CAI are not entirely distinct and disjoint components as illustrated in Figure 1.2. The primary areas of commonalty are control functions and the hardware used. CMI provides overall external control for CAI. However, internally CAI provides control for its own processes in the form of an operating system and externally must interface with the CMI system.

Material presented by CMI is generally not instructional but rather related to administrative tasks and evaluation processes, such as testing or collecting statistical

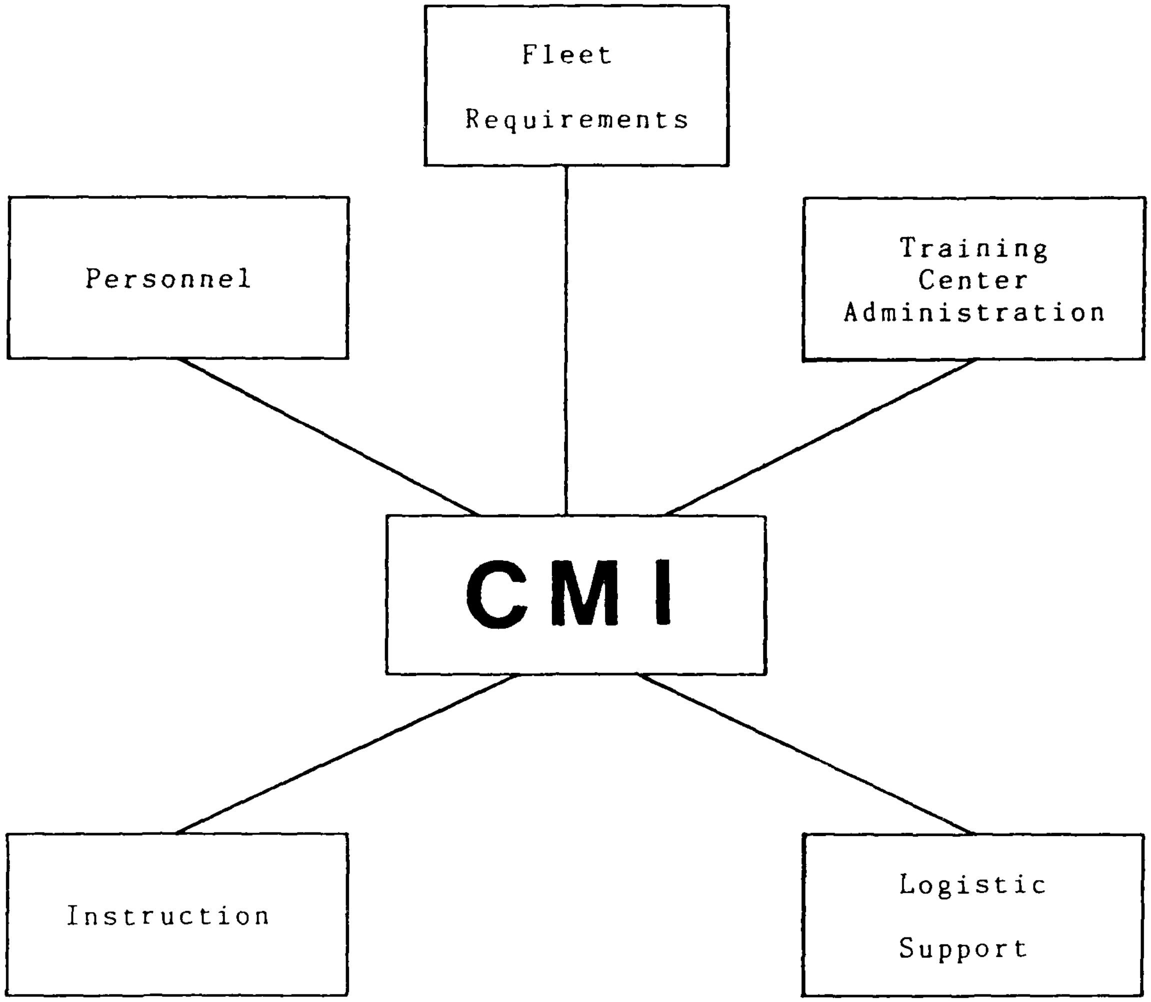
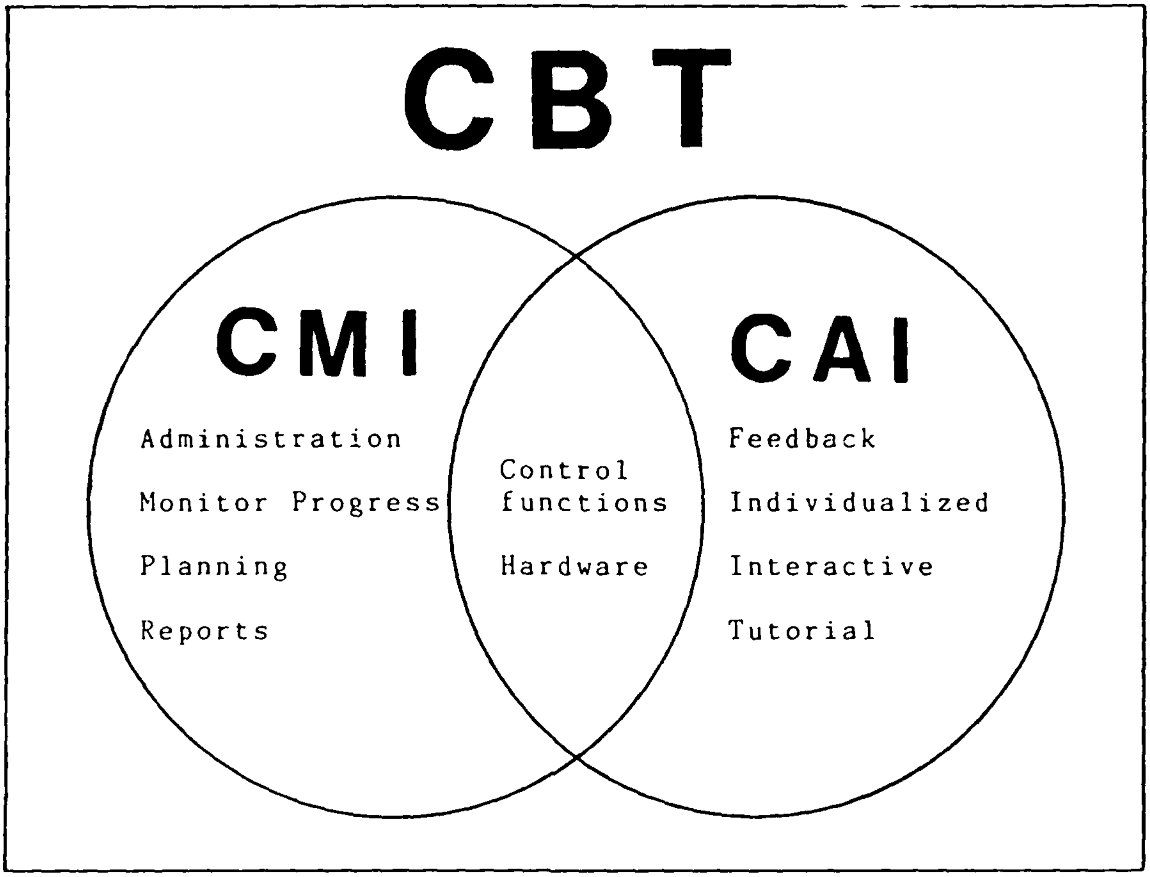


Figure 1.1 Major Components of a Training Center [Baker 81:p. 28]

information for a database or a report. CMI is not necessarily conducted in real time and students and instructor generally share a few workstations. CMI is inherently of more benefit to the supervisor of training or the instructors. This is because it simplifies many of the routine administrative facets of their jobs, freeing them to spend more instructional time with trainees.



CBT = Computer-Based Training

CMI = Computer-Managed Instruction

CAI = Computer-Aided Instruction

Figure 1.2 Components of Computer-Based Training
[Dean 83:p. 132]

CAI is instructional in nature and can provide intensive training. More workstations are required per student because of its interactive and individualized character. Trainees inherently receive the most benefit from the tutorial nature of CAI.

B. NEED FOR RESEARCH

There are various ways to create and present instruction and training. Each way highlights different aspects of the teaching-learning process. One way depends on a "master" teacher. The teacher, working alone, creates material or chooses content and presents training directly to students. Some historical examples of great teachers are Buddha, Confucius, Jesus, Mohammed and Plato. However, a great teacher is very rare indeed and generation of original training ends with his or her death.

A second way focuses on the student. The teacher provides an environment for learning but the student must take the initiative and is primarily responsible for learning. This has the distinct disadvantage of allowing a long or uncertain period of time to attain a specified level of skill or knowledge. Finally, the student "may not be able to get there from here" without intervention from a teacher or other external stimuli.

Another way relies on "expert" logic. A problem is defined, a solution is proposed and implemented, data gathered from the resulting training process and the results analyzed. The analysis and feedback are used to make revisions for improving the training process. Once a good "formula" for effective training is found, it can be replicated or adapted to other uses. As a practical matter, this systems approach is applied to virtually all training programs.

Instructional Systems Development (ISD) is a process which provides a general systems approach with multiple components, operating within a certain set of constraints, to produce an instructional system. [Logan 82:pp. 1-3] CBT is frequently generated with ISD.

CBT has often been applied directly to existing training methods. Just as there is no "cookbook" solution for ISD, there is no "best" way to do CBT. As a consequence, for most existing CBT, instruction could be done satisfactorily without a computer. This is not to say that CBT is ineffective. In certain situations, CBT can be and is very appropriate. [NPRDC TR 84-54, 84:pp. 4-19]

This research integrates computer-based processing and training objectives with Database Management System (DBMS), Decision Support System (DSS) and Expert System concepts. The focus is on CBT development and implementation, for the Navy's Maintenance Training Improvement Program (MTIP). CBT development has not adequately recognized the formidable record-keeping requirements of a typical military training program. Thousands of learning objectives must be developed, cross-referenced, tested and taught. Additionally, CBT streamlines record-keeping and facilitates the CBT process to provide management information for better evaluation and monitoring. CBT users need the ability to customize and adapt CBT to provide the best training possible. [NPRDC TR 84-54, 84:pp. 10-11]

C. BENEFITS OF STUDY

Training innovations have been described as having an unusual three-stage life cycle. In the first stage, advocates of the innovation proclaim its usefulness and success. CBT may be considered such an innovation. In stage two, indiscriminate use becomes widespread, often without sufficient development, planning or training for intended users. In the final stage, the innovation's shortcomings become apparent from experience. Criticism and skepticism grow, but come too late in the process to help and hasten abandonment of the technique in favor of another new innovation. The cycle begins anew. [NPRDC TR 84-54, 84:p. 14]

A benefit of this study is a contribution to breaking or modifying the cycle for CBT applied to training programs such as MTIP. CBT must be thought of as a combination of learning theory and computer technology. The best CBT; however, results from the development and recognition of CBT itself as a new technology. Ultimately, this improves the methods and processes for providing training. For example, naval aviation maintenance personnel use of MTIP with refined CBT would produce better trained and more qualified technicians. This results in less time spent for maintenance and improved quality in the maintenance performed. These factors will significantly contribute to higher sustained readiness for today's modern sophisticated aircraft, support equipment and systems.

D. SCOPE OF STUDY

This research is applicable to related aspects of existing and future computer-based education, instruction and training. The study evaluates a limited military application for the use of CBT to further enhance MTIP. The training of enlisted naval aviation maintenance personnel is the target. Such an environment is characterized as having standardized procedures and uses easily verifiable data. The training is required for a large number of people and must be conducted frequently. A wide variety of students must finish training with a minimum level of skill and knowledge.

Research is based on current books, periodicals and technical reports. Application is made to the military training environment. Recommendations based on the research are intended to support management policy-making to provide the best CBT for the military maintenance training environment with the resources available.

E. THESIS ORGANIZATION

Chapter II provides a brief historical perspective of CBT. Examples are given of potential future applications for CBT.

In Chapter III the fundamentals of database processing are described. Examples are given of how the Navy can and does use database management in CBT. The chapter concludes by enumerating several major advantages and disadvantages of database processing.

Chapter IV explains features of Decision Support Systems (DSS). The attributes of the DSS major subsystems--data management, dialogue management and model management--are presented. Ways in which DSS can be applied to CBT and Navy training programs, especially MTIP, are described.

The chapter also discusses Expert Systems used for training. The three major problems of using Expert Systems for knowledge acquisition are presented and a model of an Expert System used for training, TUTOR, is illustrated and described.

Chapter V is about specific issues of CBT and the Navy's Maintenance Training Improvement Program (MTIP). Instructional Systems Development is presented as the preferred method of CBT introduction for MTIP.

Chapter VI follows with conclusions and recommendations about the impact and effectiveness of CBT on the MTIP and Navy training programs in general.

II. BACKGROUND

A. HISTORICAL PERSPECTIVE

Early developments in Computer-Based Training (CBT) were in the realm of Computer-Managed Instruction (CMI). CMI served as the foundation on which Computer-Aided Instruction (CAI) was built. CMI provided an environment which promoted and fostered CAI development as more cost efficient while providing more effective learning.

Several reasons contribute to the CMI evolution as a foundation on which CAI developed to form the principle components of CBT. First, computer hardware was very expensive. Budgets did not provide funding for high start-up costs of computer equipment and facilities for CBT. In many situations it was not economically feasible to replace conventional instruction with CBT or to initiate CBT to meet an unfilled training need.

Additionally, computers were difficult to use without extensive training. Most people could not readily use computers and their use was not conducive to the direct learning process. Computer literacy was low. Thirdly, the software for CBT was very limited in quantity and the quality needed to build dynamic learning systems. Presently, sophisticated software is readily available which is much more supportive of the active, natural learning process for a large number of people.

Several early systems were developed and have become well known. First among these is PLATO (Program Logic for Automatic Teaching Operations). It was originally developed at the University of Illinois and has now matured over two decades. It is currently marketed by Control Data Corporation. TICCIT (Time Shared Interactive Computer-Controlled Information Television) was developed by the Mitre Corporation and Brigham Young University. It was marketed by the Hazeltine Corporation beginning in 1976. Finally, AIS (Advanced Instructional System) is a system developed by McDonnell Douglas Corporation in conjunction with the Air Force Human Resources Laboratory. [Kearsley 83:pp. 70-74]

The U. S. Navy is regarded as a pioneer in early CBT research and development efforts [Hansen 75:p. 7]. These early efforts were in the area of CMI and later evolved and matured into the broader manifestations of CBT. In the 1950's and 1960's, the Navy, through the Office of Naval Research (ONR) (as it was known then), sponsored and directed CMI research by various university and other organizational research centers. The Naval Training Research Laboratory (NTRL) (as it was known then) was established. CMI was initiated at the Naval Air Technical Training Center (NATTC), Memphis in Millington, Tennessee.

Although leading in development and research, the Navy was somewhat slower to implement early CBT than the Army or Air Force [Fletcher 86:pp. 183-197].

However, the Navy, as well as society as a whole, found itself surrounded by increasing technological sophistication. People were required to master more complicated subject matter and display more technical skills. Technology brought advances, i.e., improvements in job performance and conveniences; but it was less tolerant of ignorance or errors in judgment. Implementation of more advanced technological skills required higher standards of performance. CBT demonstrated a method of learning which reduced cost while increasing learning effectiveness.

Technology increased productivity with a positive return on the investment of resources. Thus there was a "technology push" to advance and further improve the state of CBT. Through CBT technology, human capabilities are extended; they are "leveraged" to improve and expand human productivity and accomplishment.

CBT differed from earlier learning methodologies predominantly in that it invoked active learning. A learner had to do something--answer a question, select a topic, ask for help, etc. Computer technology was combined with learning. It also provided the avenue for a person to learn interactively from a machine or a computer controlled system. Although training systems could be developed which were passive, the most effective systems were those which were interactive.

B. REASONS FOR COMPUTER-BASED TRAINING

The rationale for CBT is fairly straightforward. It has long been recognized and accepted that no two people learn at the same rate, i.e., learning abilities vary considerably. Each person can learn most effectively when the sequence of instructional material, the pace and mode of instruction and even the style of presentation are tailored to his individual capabilities and desires. CBT offers an opportunity for highly individualized and selective training [Lynch 71:p. 4].

Almost all CBT applications are developed by the need to improve cost efficiency and learning effectiveness. While these are fairly general goals, they normally manifest themselves in more specific objectives [Kearsley 83:p. 2 ff]. Some of these more specific reasons for CBT are illustrated in Table 2.1. These reasons are amplified individually and some potential future considerations are presented in the following pages.

1. Improved Control

Training can be made uniform and established at a desired level of standardization which is optimal for the organizational needs. Consider the case of a maintenance training course where trainees must spend time practicing

TABLE 2.1 REASONS FOR COMPUTER-BASED TRAINING
[Kearsley 83:p. 2]

1. Improved Control
2. Reduced Resource Requirements
3. Individualization
4. Timeliness and Availability
5. Efficient Use of Training Time
6. Improved Quality of Training
7. Discretionary Management of Training
8. Change Agent
9. Improved User Satisfaction
10. Consistency
11. Reduced Development Time

repair of actual equipment malfunctions. Before students attempt the repairs, CBT can provide control to ensure that proper trouble-shooting techniques are taught and followed and that good diagnostic skills are developed. With a solid basis of theoretical and procedural training, trainees may further develop and refine their new skills with actual physical "hands on" training. The entire learning process is controlled and evaluation of learning accomplished is not based only on certain checkpoints along the way. The process itself as well as the achievements are open to inspection and review.

Computers also improve control by facilitating the administrative functions of the training system. These functions are in the realm of CMI. They may include registering students, assigning training schedules, generating and scoring tests, producing required reports, distributing instructional material and other necessary functions.

CBT can be used to monitor student progress. Students receive instruction which is intended to provide at least a minimum level of comprehension and result in improved job performance above a standard level. However, comprehension rates vary from person to person and subject to subject. Improved control can ensure that these differences are quickly identified and action taken to provide optimum scheduling and assistance to promote student mastery of the subject material.

2. Reduced Resource Requirements

An established CBT system can reduce resource requirements. However, significant, high start-up costs must be considered when implementing a new CBT system or converting from a conventional training program to CBT. These initial costs must be weighed against the life cycle benefits to be gained from CBT, including future rapid assimilation of state-of-the-art training improvements which may be obtained from later CBT developments.

CMI may reduce resource requirements by necessitating fewer people and facilities to maintain records and administer a training program. This reduces some of the overhead costs of training. CBT is individualized and tends to reduce training man-months. Therefore, fewer instructors, classrooms and instructional materials are required for a given student load compared to conventional training.

CBT permits higher student-to-instructor ratios. Routine aspects of training may be accomplished more efficiently by CBT and instructors have more time to help students with problems. The CBT system can, in fact, pinpoint specific problems of each student for the attention of the instructor.

Another important reduction in training resources from CBT is the use of computer-based simulators and trainers instead of actual equipment, such as aircraft, for training. Hands-on practice with actual equipment is critical to some training programs. If equipment is unavailable, crucial trouble-shooting or diagnostic training may be diluted. Computer-based simulators and trainers can provide realistic practice without the full cost of actual equipment. Finally, computer graphics can provide a student with a broader understanding of equipment operation than is possible with mere practice on actual static equipment in the training environment.

3. Individualization

Individualization has always been a principle objective of CBT because of the efficiencies it brings to the learning process. Each student is allowed to learn at his own pace and in the fashion most suited to him. This results in substantial time savings to complete training (See Table 2.2). In conventional training, instruction is often geared to a set pace based on the aggregation of past student performance. Thus training time for each student is the same even though student learning abilities may vary widely. Individualization, as provided by CBT, allows students to learn at their own pace and, thereby make better use of total training time.

CBT systems also allow students some control over the sequence of instruction. While completing a training course, for example, students may spend more time with topics they find difficult to master and less time with topics they understand. CBT may also give students more discretion in scheduling their training time.

Students begin training with different past experiences, levels of skill and knowledge. With CBT, student skill and knowledge levels may readily be assessed at the beginning of training and during execution. An individualized training program may be created which best matches the needs and abilities of the student and the requirements of the organization for which the training is conducted. Maximum benefit may be obtained from a training opportunity. CBT can aid the training manager's decision-making; more to come about that later.

Individualization is important for remedial instruction conducted during or after training. The Navy frequently uses remedial training in "A" schools and as part of the Maintenance Training Improvement Program (MTIP). CBT can identify specific problem areas and provide assistance to ensure that each student completes training with an acceptable level of skill and competence.

4. <u>Timeliness and Availability</u>

CBT provides significant advantages over conventional classroom training by being able to provide training "on demand." Training can be provided at the right time and in the right place. Students need not wait for specific training to become available. Pertinent training can be made available exactly as required.

Students typically are provided certain training periods when they are absent from their normal jobs. During these periods they may be given an entire syllabus of training for immediate and future needs. Unfortunately, much of the training for future needs is often forgotten or becomes obsolete by the time it is needed. CBT allows training to be provided in smaller, more directly applicable packages.

CBT has the potential to provide training at remote sites. The training can come to the students instead of the students going to the training. Much of the travel time and expense for training can be eliminated. The training can be dispersed by providing instructional material to each requiring site or by distribution over a computer network from a central facility.

Finally, students are able to learn about new equipment before it has arrived through CBT trainers or simulators. Thus they are more proficient in operating the new equipment when it does arrive. Students may also be trained in new maintenance procedures and techniques as soon as they are introduced.

5. Efficient Use of Training Time

With CBT, trainees can obtain the same level of learning in less total time than with conventional instruction. However, CBT is not a training panacea. In the military setting, where large numbers of people need training frequently, it may be very appropriate [Dean 83:p. 150]. For example, a study of the effectiveness of CBT in the military demonstrated time savings of about 30 percent based on findings for Air Force and Navy training [IDA P-1375, 79:pp. 5, 83]. See also Table 2.2.

More efficient use of training time is almost completely attributable to individualization. Thus non-computerized training could also be made more time efficient with more individualization but probably at higher cost. However, as a practical matter, it is virtually impossible to establish and manage a large individualized training program without the use of a computer.

With a CBT system, an assessment of student skill and knowledge levels may be facilitated prior to and during a training course. Then a course of instruction may be promptly created and modified along the way to provide the student with the most learning potential for the training time available. The student's time is not wasted going over subjects he already knows and understands. Rather, he is challenged with unknown material and can make better use of the training time.

More efficient use of training time permits students to train but spend less time away from their normal jobs. Sometimes, the length of training is the criterion for determining if that training can be taken or not. CBT has the potential, under favorable conditions, to provide the most training for a specified time period or provide specified training in the minimum time.

The efficiencies of CBT may require changes to an existing training system and organization. Conventional training systems built around fixed schedules must change to take advantage of CBT. For example, when the Navy first introduced CBT, training assignments remained on a fixed schedule. Most students finished their training early and were assigned undesirable tasks, i.e., watchstanding, recruiting duty, mess cooking or clean-up detail, while waiting for their scheduled training time to end. The word quickly spread that finishing training early was not a good idea and training completion time actually increased to nearly match the scheduled time. The Navy soon changed the assignment procedure from fixed duration to a continuous method and the problem disappeared. [Kearsley 83:p. 10]

6. Improved Quality of Training

Quality of training is difficult to measure and prone to subjective evaluation. Criteria may be established by which to appraise quality and measure effectiveness. The measurements may be direct or indirect. Direct measurements are those which gauge training based on evaluation of the training process itself and not its effectiveness. Indirect measurements are those which gauge training quality based on evaluation of the results of training. Both direct and indirect assessments may be important. Direct results provide immediate indications of discernible deficiencies which are usually readily correctable.

The ultimate measure of the quality of training is, however, its effect on improving subsequent job performance, an indirect and subjective measure of training quality. The purpose of training must be to improve job performance and that must be held at the forefront of all training programs. The users of CBT must evaluate its impact on improving job performance. High quality training should translate into improved subsequent performance in an existing job or lead to high quality initial job performance.

Orlansky and String have compiled approximately 30 studies (48 sets of data) which report on the effectiveness of CAI and CMI in military training. These results are presented in Table 2.2.

CBT provides several features which tend to improve the quality of training. In interactive, individualized instruction (such as good CBT), students spend a much higher percentage of time involved in the process and learning, i.e., students participate more in training than in conventional instruction. Secondly, CBT can provide pertinent feedback to trainees and instructors. Feedback may reinforce positive accomplishment in the form of messages and new assignments. Instructors may also intervene with praise, recognition or provide special privileges. Feedback may also suggest corrective action for less than satisfactory progress thus ensuring that training meets at least the minimum of established quality standards.

CBT may be used to improve job performance directly or indirectly. In the direct approach, students are trained in specific skills for their immediate job situation. An

TABLE 2.2 SUMMARY OF FINDINGS FOR MILITARY CAI AND CMI, COMPARED TO CONVENTIONAL INSTRUCTION [IDA P-1375 79:p. 84]

Measure		Findings		Comments
		CAI	CMI	
Student Achievement		Same or more	Same	Performance measured only at school. Relation between performance at school and on the job not demonstrated. Observed differences not of practical importance.
Course Completion Time				CMI: Most time savings maintained or increased with extended use.
	No. of Comparisons	40	8	
	Time Saved (Median)	29%	44%	
	Range	-31 to 89%	12 to 69%	
Student Attrition		About the Same	Slight Increase	CAI: Very limited data CMI: Possible decline in student quality
Student Attitude		Favorable	Favorable	
Instructor Attitude		Unfavorable	Unfavorable	Very limited data. Little attention given to instructors.
Cost		Less, due to student time savings	Less, due to student time savings	Data limited and incomplete.

example is inservice training such as the Navy's MTIP. Job performance is expected to improve as students are trained in specific skills for their immediate job situation. Job performance is expected to improve for a particular job role. Using an indirect approach, instruction may be provided which is more general purpose and more broadly affects job performance, such as remedial instruction in mathematics, reading or finance. This training may be helpful for many jobs and in the student's personal life as well.

7. Discretionary Management of Training

CBT may be more accommodating and flexible than conventional training to trainees and employers of trainees. These characteristics may lead to improved morale and productivity.

Students have, within limits, the freedom to pursue training at their own pace and to fit their own preferred schedule. More time may be spent on topics which are more interesting to the student or which require more time to master. The trainee may receive feedback to indicate areas requiring more study or to confirm perceived levels of training comprehension.

Managers--those who supervise training programs and those who send trainees--are afforded more professional discretion in their positions. A training course can be started at any opportune time. It is not imperative that a class schedule be set and then quotas filled with students for training to be conducted. Courses of instruction can be easily modified or updated as valid needs arise with good database management as discussed later. Additionally, CBT provides the technology to provide training to the user sites, if warranted, rather than requiring that training be conducted at a central training facility. Courses may be readily tailored to the needs of individual customers.

With computer technology becoming ever more ubiquitous and widespread, CBT provides the opportunity for students to work with and learn on a computer system. As they learn, they also become familiar with a computer system. They may even be able to learn on a system which is identical to or similar to one they will use in their job.

8. Change Agent

CBT is a different way of presenting training than conventional classroom instruction. It is an alternative way to accomplish common or more ambitious goals. CBT can provide many benefits as described here. Incorporation of CBT in an organization will require managerial change as well as technological change to realize its maximum benefit [Kearsley 85:p. 61 ff, and 83:p. 13-14, Seidel 81:p. 211 ff]. For example, application of a computerized Database Management System (DBMS) or Decision Support System (DSS) makes more sense with CBT than with conventional instruction. More about this in later chapters.

Note that change is made for organizational benefit and not merely for the sake of change. Change is made to provide a suitable environment for the new training system and an atmosphere in which it can function best. Effectiveness measures must be examined and re-evaluated. Instructor roles and functions must be made compatible with CBT. Users of CBT must learn how to use a computer. These are some of the most apparent changes driven by introduction of CBT.

CBT allows changes in instructional materials and methods to be made quickly. There is no need to print and physically distribute changes to all concerned parties. Changes can be made in the computer system and are rapidly available to all users. If common CBT is conducted at more than one site, changes can be distributed and incorporated electronically. Potential system modifications may be tested in CBT by pilot, phased or prototype projects before being approved for system wide use.

Because CBT is very accommodating to change, it promotes change. The wide variety of training presentations, i.e., text, graphics, trainers, simulators, encourages developers to create potential improved methods, material and equipment to deliver training. As these become proven and accepted, they can be implemented as constructive changes to a CBT system.

9. Improved User Satisfaction

Instructors may find improved professional satisfaction in CBT because the system facilitates many of the administrative and routine functions required of them. More of their time may be spent helping students and monitoring student progress. It is also easier to keep training material current and pertinent. When compared to conventional instruction, CBT offers high potential to provide many more training resources to instructors.

In the training environment, student aptitude and attitude are important considerations for successful learning. CBT can stimulate positive attitudes. Student participation in the learning is high, leading to higher self-satisfaction with learning accomplishment. Students can somewhat tailor the sequence and pace of training to their personal style and are more involved in the learning process. [Kontos 84:p. 4]

CBT, especially graphics, trainers and simulators, can provide more realism to training compared to conventional classroom training, thus giving the student more of a sense of purpose and achievement. Rapid response time and feedback are CBT characteristics which improve user satisfaction with the system. Additionally, students can assess their progress during training and that creates a sense of accomplishment and satisfaction. Improved satisfaction leads to increased motivation which strongly complements any level of trainee aptitude. Together these tend to improve training productivity and reduce (possibly eliminate) training course failures.

10. Consistency

Human instructors can have an "off day" or miss a day because of illness or personal reasons. This interrupts a course of instruction. A substitute instructor will most likely not present the same material in the same manner as the originally scheduled instructor would have. With CBT more consistent training can be presented to trainees.

During development, subject matter experts (SME) and training designers may work together to create material to cover a topic to meet course objectives. The consensus of these expert opinions can result in a computer-based course of instruction that will satisfy course objectives each and every time it is presented.

11. Reduced Development Time

Training materials often require modification as procedures, regulations or equipment change. In fact, out-of-date materials is a major cause of ineffective training and dissatisfaction with training. Authoring can be facilitated with CBT. Also, making revisions to existing material based on new developments and implementing them is, frequently, time-consuming and difficult. CBT streamlines the revision process.

12. Future Enhancements

Computer hardware costs have decreased dramatically while capability has increased greatly. If future advances are to be realized, CBT must be established as a foundation on which to build. Two most likely future advances, which may already be found in very limited use, are discussed in the following paragraphs.

a. Embedded Training

Embedded training refers to integrating training functions directly into weapon, aircraft or maintenance equipment systems. Embedded training is a facet of CBT which is developed with the corresponding equipment or system as an integral part of it. An advantage of embedded training is that it is very specialized training in which a person is taught on and by the actual equipment or system he will be using. Secondly, the training should be of high quality since it is produced by the same source as the equipment or system and designed specifically for that equipment or system. Also, training may be conducted in the field and is not limited to training facilities; it is available wherever the equipment or system is located.

b. Networks

Communication networks will permit training to be readily distributed to many users. Small users, who would not normally be candidates for a CBT system, may have access to CBT via a network. Modifications to existing training material and new training material may be easily incorporated into the CBT system with virtually no delay and are quickly available to users.

Networks allow for greater physical security by distributing duplicate programs and databases at various locations in the network. This may also permit the CBT system to function even though part of it is down for scheduled maintenance or other unplanned reasons.

C. DISADVANTAGES OF COMPUTER-BASED TRAINING

A major disadvantage of CBT is high start-up costs. These are generally one time costs for system development, facilities, hardware and software. As development is completed, equipment is procured, installed and tested. Additionally, the recurring or maintenance costs for the system must be considered for the life cycle. The benefits to be gained from a CBT system must be weighed against these costs.

Rapid obsolescence may be another significant disadvantage. Computers, as instructional tools, appear to be at a rudimentary state of development [Bork 87:pp. 201-206; NPRDC TR 84-54, 84:p. 1]. Breakthroughs or rapid development in computer technology or CBT may make existing equipment or systems impractical or obsolete in terms of training effectiveness before their costs are recovered.

Unfortunately, computers can be manipulated or "gamed" by students. Part of this phenomenon has been formalized as Parkinson's Law which states, "Work expands so as to fill the time available for its completion" [Parkinson 57:p. 1].

Another disadvantage is that while student attitudes generally appear favorable toward CBT, that of instructors has been unfavorable in some cases (See Table 2.2). Contributing to this is the fact that instructor roles have not always been clearly defined nor expectations described for CBT [NPRDC TR 82-45, 82:pp. 24-25].

CBT may also limit constructive interaction among students as they learn. As students learn individually, they may not advance and refine interpersonal skills which may be needed to work in more cooperative team roles for future jobs.

D. SUMMARY

The chapter has presented a brief history of CBT including some examples of early systems. Mentioned are some of the conditions and requirements which promoted CBT. Several reasons are presented for using CBT; these reasons generally contribute to training cost reductions and/or improved learning effectiveness. Also, some additional potential future uses of CBT were suggested. Finally, some of the major disadvantages of CBT, such as high initial and maintenance costs, were described.

The Maintenance Training Improvement Program (MTIP) is a CBT system and embodies several of the characteristics given for CBT. CBT can allow MTIP to be further improved and provide a foundation for future developments and enhancements as discussed later.

III. DATABASE MANAGEMENT APPLIED TO COMPUTER-BASED TRAINING

Data is a very important resource in a Computer-Based Training (CBT) system. Data includes facts and figures about reality from which information may be drawn and conclusions made. Information is selected data about specific circumstances or subjects which convey new meaning to a receiver. Knowledge is general understanding based on experience and education or training. Knowledge, either personal or expert, is applied to applicable information for decision making. [Harmon 85:pp. 30-31, Kroenke 87:p. 41, Wiederhold 86:pp. 78-79] The data held by a CBT system is *fundamentally important* to trainees, instructors and managers. The foundation on which CBT is built and functions is provided by data.

A CBT system must be able to receive or gather data. There may be many sources of data. For example, data for training may be obtained from equipment manufacturers or operators, or from other military organizations in the form of specifications or procedures. Data may be generated internally within CBT as the system is used. Users of CBT usually must provide some data to the system to be able to use the system. Other data stores, books, manuals, etc., may provide data to a CBT system.

Data which is input into the system must be subject to verification and periodic checks made to ensure the accuracy of all data. Once data is received and entered into the system, it must be capable of being accessed and processed in a reasonable time. Finally, data in a CBT system must be secure. Data should not be lost or easily stolen. Protection from unauthorized tampering, altering or copying must be provided. One common method of ensuring integrity is through data duplication. The capability to add, edit or delete data must be restricted to a few trained and authorized responsible individuals.

Data and the subsequent information it provides are important to CBT users in slightly different ways. Students rely on data to provide information for training and learning. Thus, the student's knowledge base is expanded which should promote improved decision-making for better future job performance. Data is converted into information and incorporated into student knowledge before it is needed. The data is used for decision making outside CBT. Feedback may point to changes necessary in the data to provide better training. This student-data relationship is illustrated in Figure 3.1.

Managers of CBT systems depend on data in a slightly different manner. For them data provides information directly for decision making about CBT itself. Information supplements existing knowledge in a more immediate situation

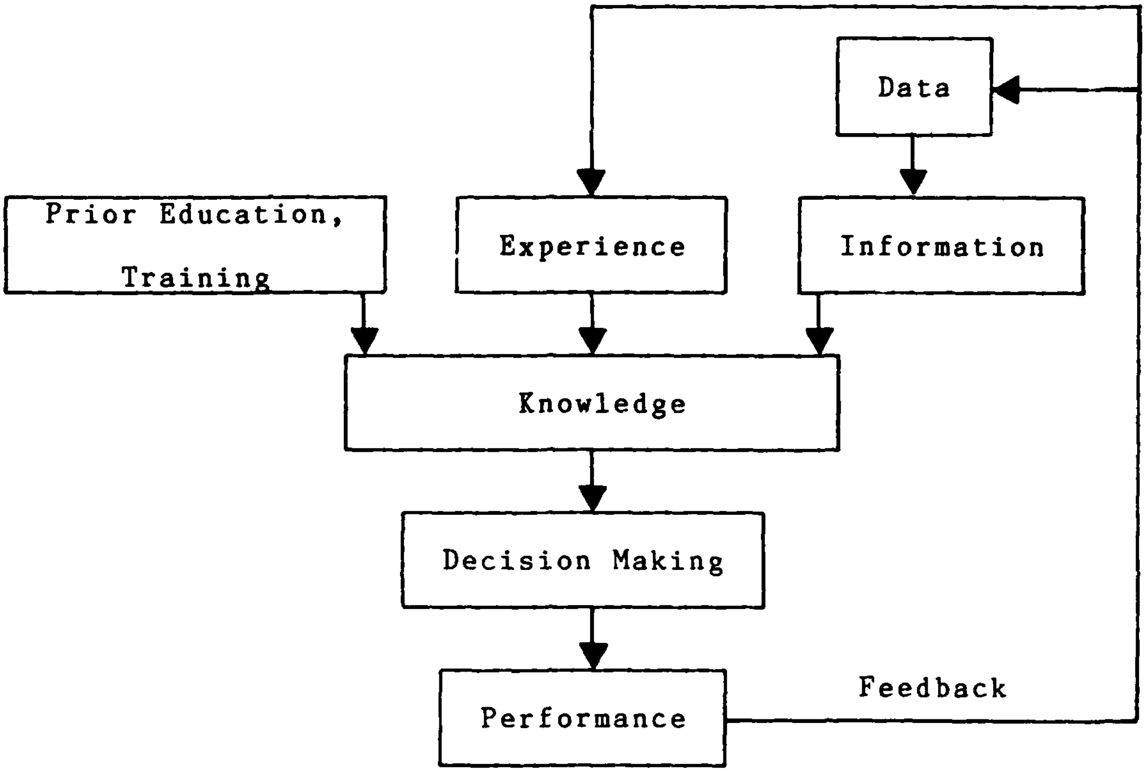


Figure 3.1 Student-Data Relationship
[Wiederhold 86:p. 78]

and through feedback becomes part of experience. The manager-data relationship is illustrated in Figure 3.2. In the next section, a description is provided of how CBT provides a Management Information System (MIS) for the management of CBT. CMI is the component of CBT which includes the MIS functions. Figure 3.3 illustrates how data and databases fit into the scheme of a CMI subsystem. They serve a very central and crucial role.

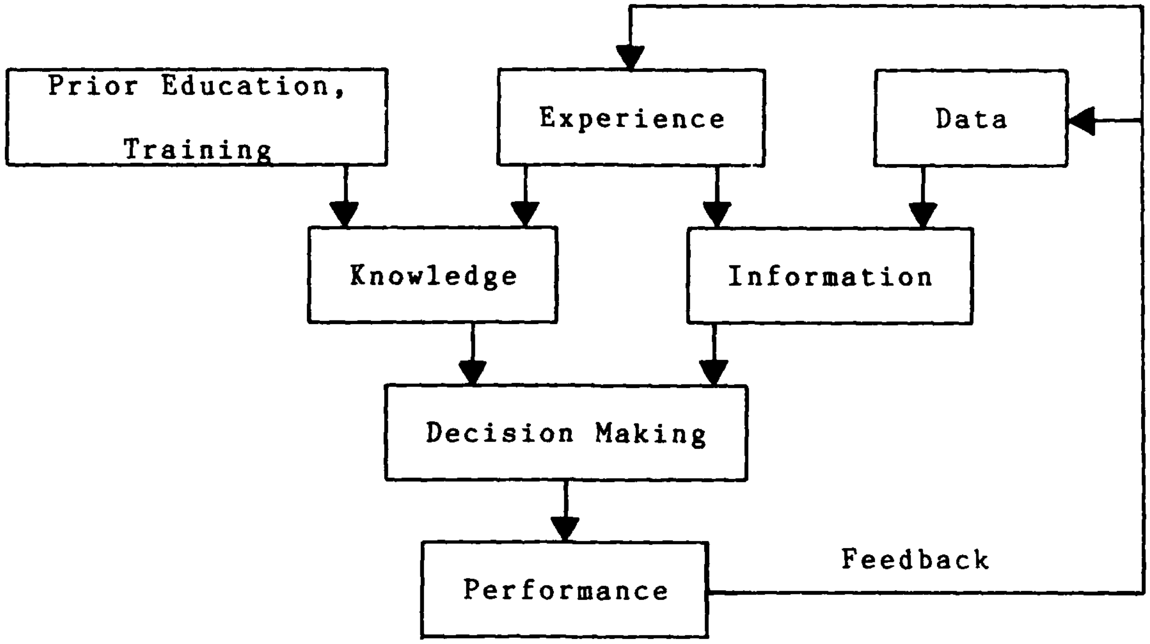


Figure 3.2 Manager-Data Relationship
[Wiederhold 86:p. 78]

A. MANAGEMENT INFORMATION SYSTEM

1. Definition

Management Information System (MIS) means different things to different people. At one extreme are those who view MIS as essentially equivalent to Electronic Data Processing (EDP). Thus data transactions are processed into scheduled reports. At the other extreme are those who believe that MIS should provide all the information which an organization needs to function effectively. Typically, much emphasis is placed on supplying management with information for decision making. [Sprague 77:p. 7]

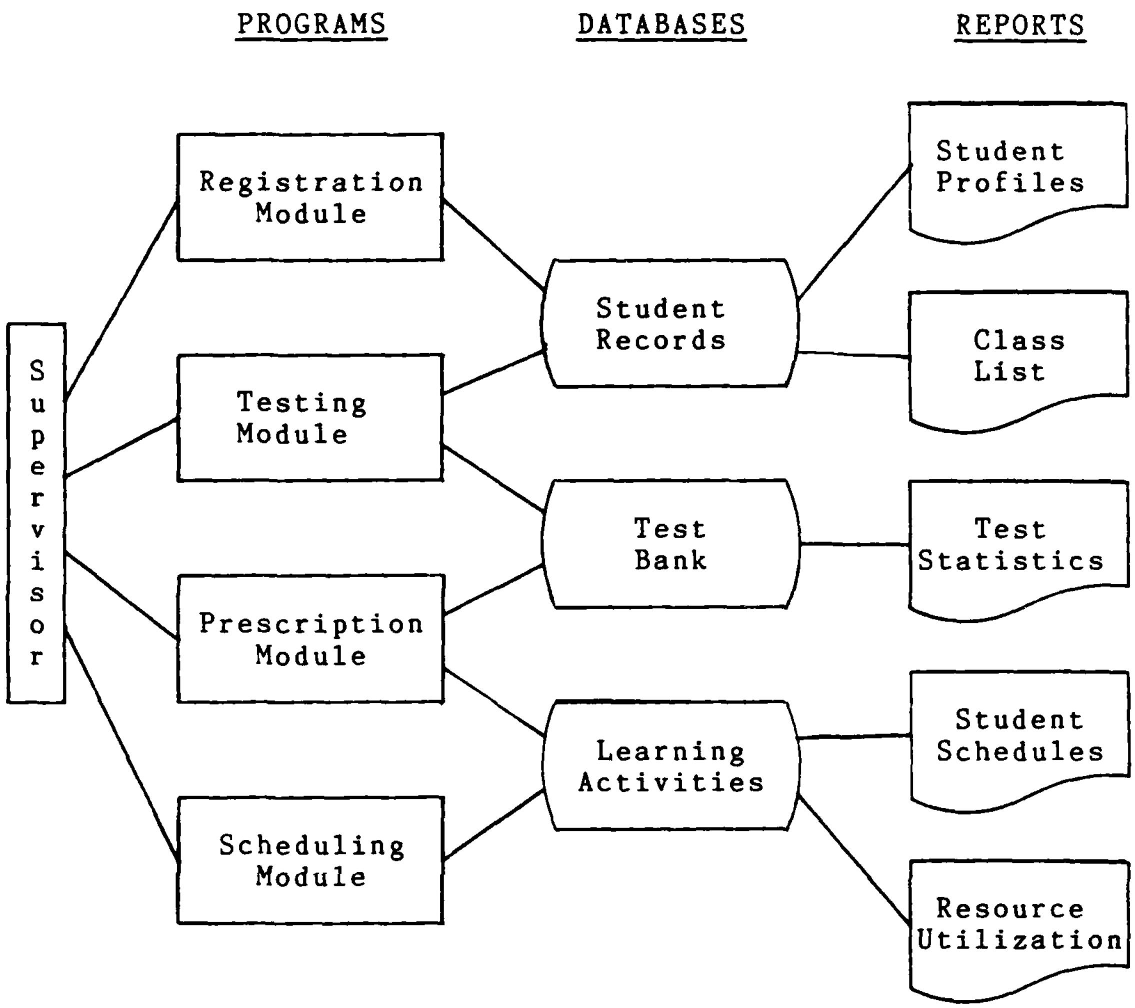


Figure 3.3 Typical Components of a CMI Subsystem
[Kearsley 83:p. 25]

Gorry and Scott Morton [Gorry 71:pp. 69-79] describe a MIS framework for managerial activities. Managerial activities are categorized as strategic planning, management control and operational control. Strategic planning is the process of establishing objectives for an organization. Through management control, managers use judgment to assure that resources are obtained and implemented effectively and efficiently to accomplish the organization's objectives. The third general function of operational control assures that system tasks are accomplished expediently and economically by carefully and previously delineated procedures.

Decisions which are required of managers may also be classified as belonging to a continuum from structured or unstructured. Structured decisions are usually repetitive, routine and follow set procedures. Unstructured decisions are novel, complex, occur infrequently and follow no set procedures. Figure 3.4 illustrates the areas of information systems generally thought of as MIS. The Structured Decision Systems (SDS) encompass nearly all of what has traditionally been called MIS.

Gorry, Scott Morton and Sprague [Sprague 80:p. 10] reject the traditional definition of MIS for a broader, more practical view in which MIS refers to the whole set of systems and activities necessary to gather, process, manage and ultimately use data and information as a resource in an organization. The area of Decision Support Systems (DSS) applied to CBT, will be discussed in the next chapter.

2. <u>Database Management as a Foundation for MIS</u>

Data from which to derive information is essential to MIS. This data consists of data elements that comprise an organization's database. In the late 1960's, Head [Head

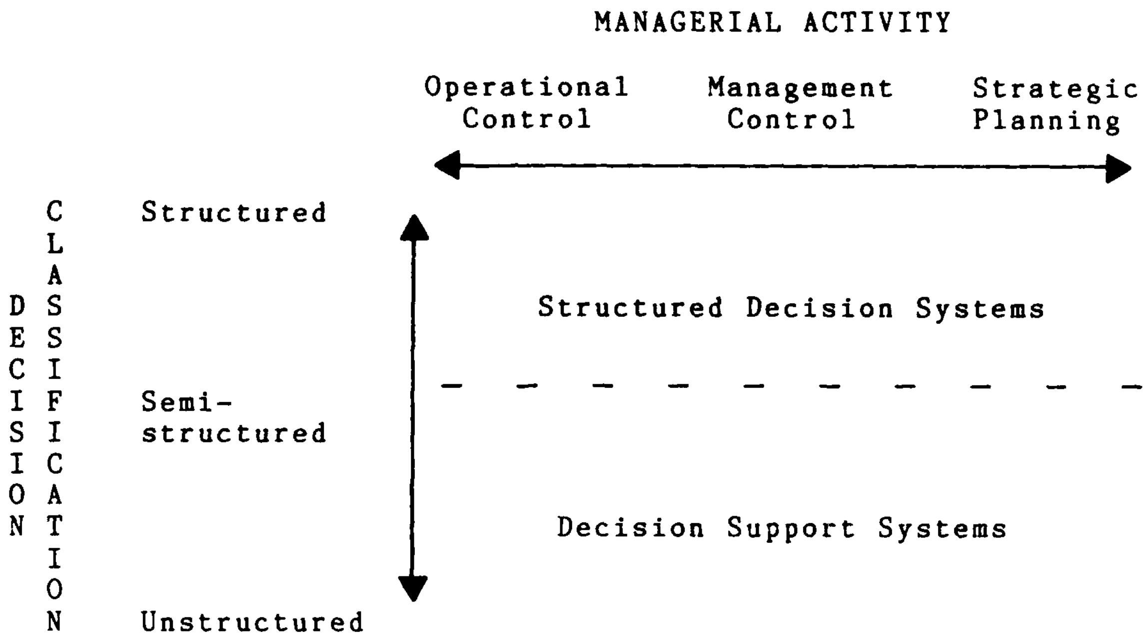


Figure 3.4 SDS and DSS in Management Information Systems [Gorry 71:p. 74]

67:p. 23] explained that to accomplish anything useful with the database, it is necessary to provide organization and structure. To do this, the information requirements of management must be identified. The data elements must be identified in technical terms: how large they are, what their meaning is, where they are stored and how one can get at them. Finally, data relationships among data elements have to be identified.

Differing levels and types of management require different types of information (see Figure 3.3). This can result in many specialized databases. In CBT, for example, instructors, training program managers and the Chief of Naval Education and Training (CNET) could each have their own specialized databases. This hierarchical or "horizontal" design matches the database with the organizational level which is its primary user. Such a database is likely of very limited or no use to others in the organization. A proliferation of specialized databases may result in much duplication of an organization's core data. Databases have also been designed functionally or "vertically" to serve all levels of management with data about a particular subject. For example, in CBT, separate databases could be maintained for student records, test bank, learning activities (see Figure 3.3) and aircraft maintenance data for the Maintenance Training Improvement Program (MTIP).

Two particular advances in technology have aided MIS development. These are the development of large data storage devices and interactive, real-time computer systems such as Database Management Systems (DBMS). The DBMS can produce a more responsive MIS and provide all levels of management with the functional information required from a common organizational database. The DBMS gives the organizational database design and structure, establishing a foundation for MIS as illustrated in Figure 3.5. The DBMS provides maintenance of the database as well as a communication network for gathering and modifying data. It also provides for inquiry to the database for flexible access and information retrieval [Sprague 77:pp. 8-9].

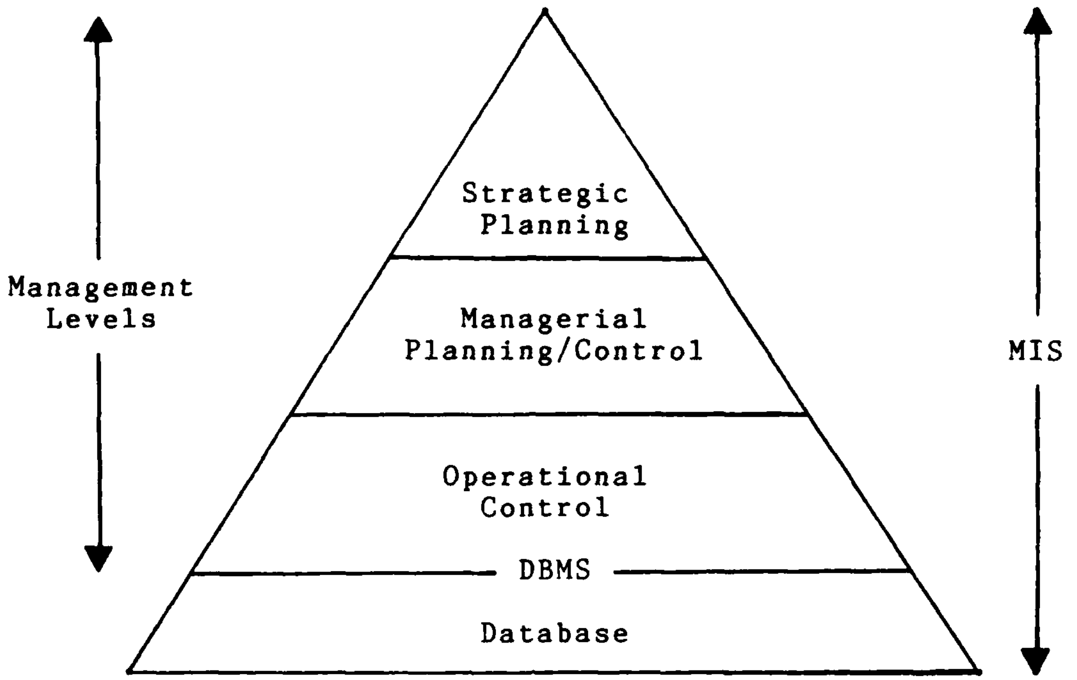


Figure 3.5 Organizational Model for MIS [Head 67:p. 23]

B. COMPONENTS OF A DATABASE MANAGEMENT SYSTEM

CBT employs an MIS which involves multiple users, multiple data files and requires multiple views of stored data. A Database Management System (DBMS) is a system of components which provides a more sophisticated approach to data management, storage and retrieval than traditional file systems. The five major components of a DBMS are considered applicable to CBT; they are: hardware, programs, data, people and procedures.

1. Hardware

With a computer installation such as CBT in place, there is very likely no need for additional specialized hardware to implement database processing. A DBMS may, however, require more memory and storage components to accommodate its increased overhead. Several characteristics of hardware which would be advantageous to CBT would also facilitate DBMS. More main memory, faster Central Processing Unit(s) (CPU) and more direct access storage may be essential for the DBMS to function effectively.

Recently specialized database machines have been introduced by manufacturers. These machines are special purpose computers whose only function is to manage the database. (See [Date 86:p. 603 ff] for a description of these machines.) Each CBT system would have to be analyzed independently to determine if such a machine could be used effectively in that system.

2. Software

Software refers to the programs used in the database processing system. Database requests and transactions may be processed in batch form or on-line by users at terminals. On-line processing uses a Communications Control Program (CCP) to receive and route requests. CCP provides communication error checking and correction. It coordinates activity among the various terminals and routes messages within the system.

Other types of programs are application programs and utilities. Application programs satisfy specific predetermined needs such as class lists, tests, learning activities, etc. They must be developed for or tailored to each CBT system. Utility programs provide a wide variety of services. They may provide for generalized update and query of the database. Software locks are included to provide security for classified data. Others establish and maintain the database and can reformat and clean-up files for more effective operation and more efficient storage.

A third type of program is the Operating System. This program controls other programs and controls the computer's resources. The operating system is usually designed for specific hardware and provided with it. The DBMS shields the user from any direct contact with the operating system. Figure 3.6 illustrates the programs involved in typical database processing.

3. People

People are an important part of the CBT DBMS. Obviously, there are users who employ the system every day for its intended function. As in other computer-based systems, there are operational and systems development personnel who are included in the DBMS.

A very prominent position in the DBMS is that of the Database Administrator (DBA). Often referred to as a single person, this may actually be a group of people. Database administration is key to providing an environment for effective DBMS employment. A function of the DBA is to manage data activity. The processing rights of all users

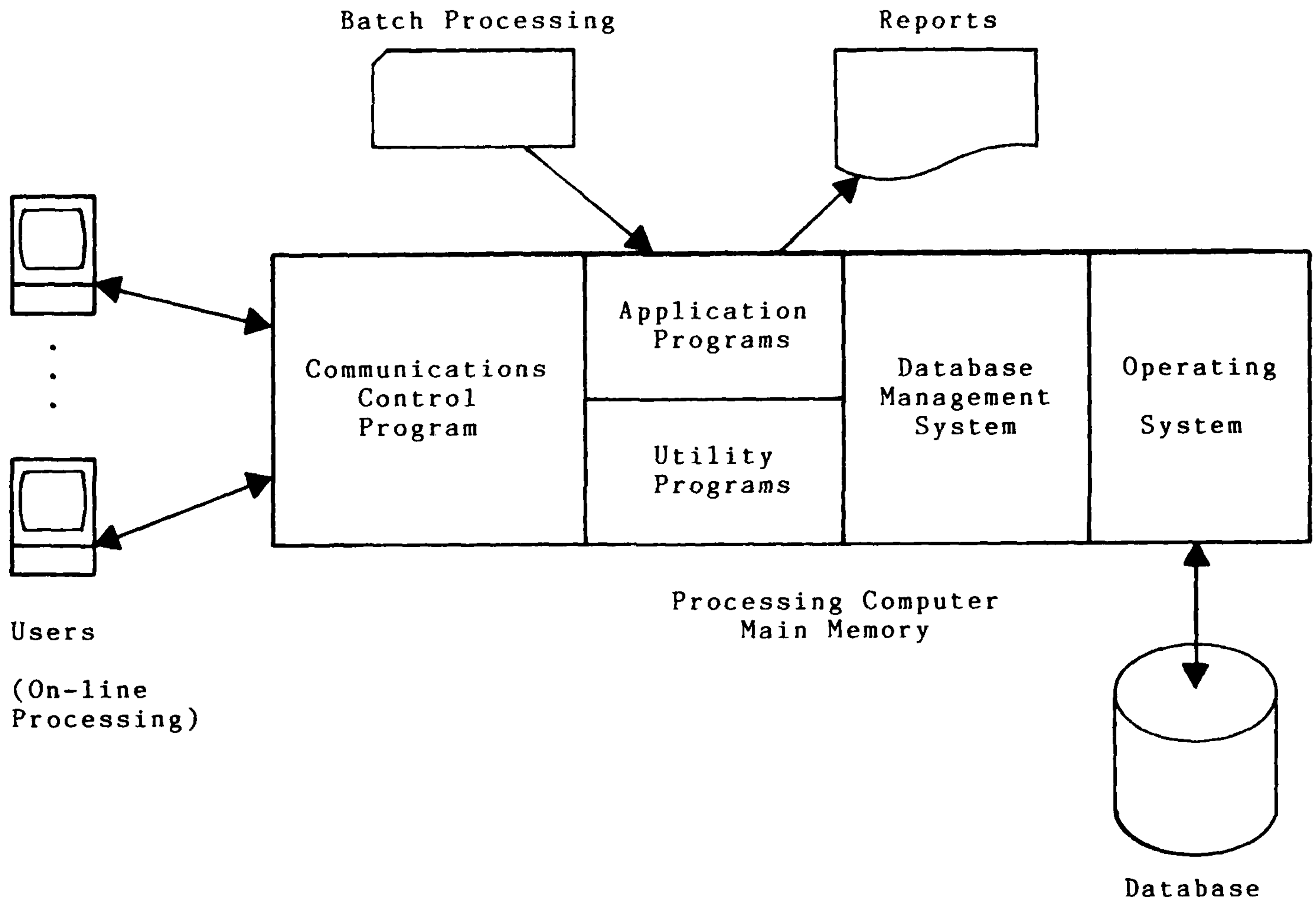


Figure 3.6 Programs Involved in Typical Database Processing [Kroenke 83:p. 9]

must be determined. The DBA is the focal point for negotiating and assigning these rights. Different users may have different priorities. In a CBT system, for example, students and instructors are likely the most frequent users and have very high priority in keeping with the mission of training.

However, required reports or management activity may occasionally pre-empt student and instructor use of the system. Tasks which are not mission critical should be scheduled for off-peak hours. Once these access rights are originally determined or later modified, they must be documented and distributed to applicable users. The DBA must also formulate additional operating procedures for such items as concurrent database update, backup of the existing database and recovery of the database in the event of system failure. A CBT application where the role of the DBA is very important is the Navy Maintenance Training Improvement Program (MTIP) which consists of many databases each requiring sound, responsive management.

The DBA is a central figure in the management of the DBMS itself. This is discussed further in the next section. Finally, the DBA is concerned with DBMS performance. A DBMS can be periodically tuned for more efficient operation in its present environment. This makes better use of existing resources to achieve system objectives. Evaluating current performance helps determine which new software or equipment to procure for future requirements. [Kroenke 87:pp. 324-327]

4. Data

As stated earlier in the chapter, data is a very important resource for CBT as a foundation for the DBMS. Data in a database is integrated and shared. The database must be self-describing, i.e., it contains a description of the database structure. A self-describing database ensures that the data remains application program independent. A DBMS should provide a data dictionary, or user-accessible catalog which describes the data [Kroenke 87:p. 317].

An integrated database is more than a collection of data files. It is a collection of files with much redundancy eliminated, but includes designed relationships among the various file records. A shared database is one where different users, through the various application programs, have access to the same pieces of data.

Data may be referred to in three additional ways in a database system. First is the logical view of all data as it would appear to humans in general. This is also known as the schema or conceptual view. Another view is the external or subschema perspective. This is a particular view by a specified user and provides different views of the same data depending on the particular perspective. There can be many overlapping subschemas for a given database and each is a subset of the general logical view. A third view is the internal or physical view of data as it is actually represented. Figure 3.7 illustrates the three views of data.

To implement the logical database, physical considerations are imposed on the conceptual model to create the physical database [Cesena 87:p. 5]. This is the view of data as it is stored and processed in a particular system. Application programs call the logical files which are stored in the physical database. The various views and relationships of data logical files as used by application programs in the CBT physical database is summarized in Figure 3.8. [Date 86:pp. 5-7, Kroenke 83:pp. 11-14]

5. Procedures

DBMS procedures are both system operating instructions and policies for system use. Procedures are established for system users and operators. Procedures may also be segregated as those for normal conditions or those for contingencies such as emergency, failure or recovery occurrences. As noted above, development of system procedures is a prime responsibility of the DBA. When establishing procedures, the requirements of all users should be considered with a view to the technical, operational and economic feasibility of each [Davis 83:pp. 38-39]. Compromises or alternative solutions must be sought when conflicts arise. Procedures should not be at cross-purposes with one another and should promote optimal use of system resources for the benefit of all users.

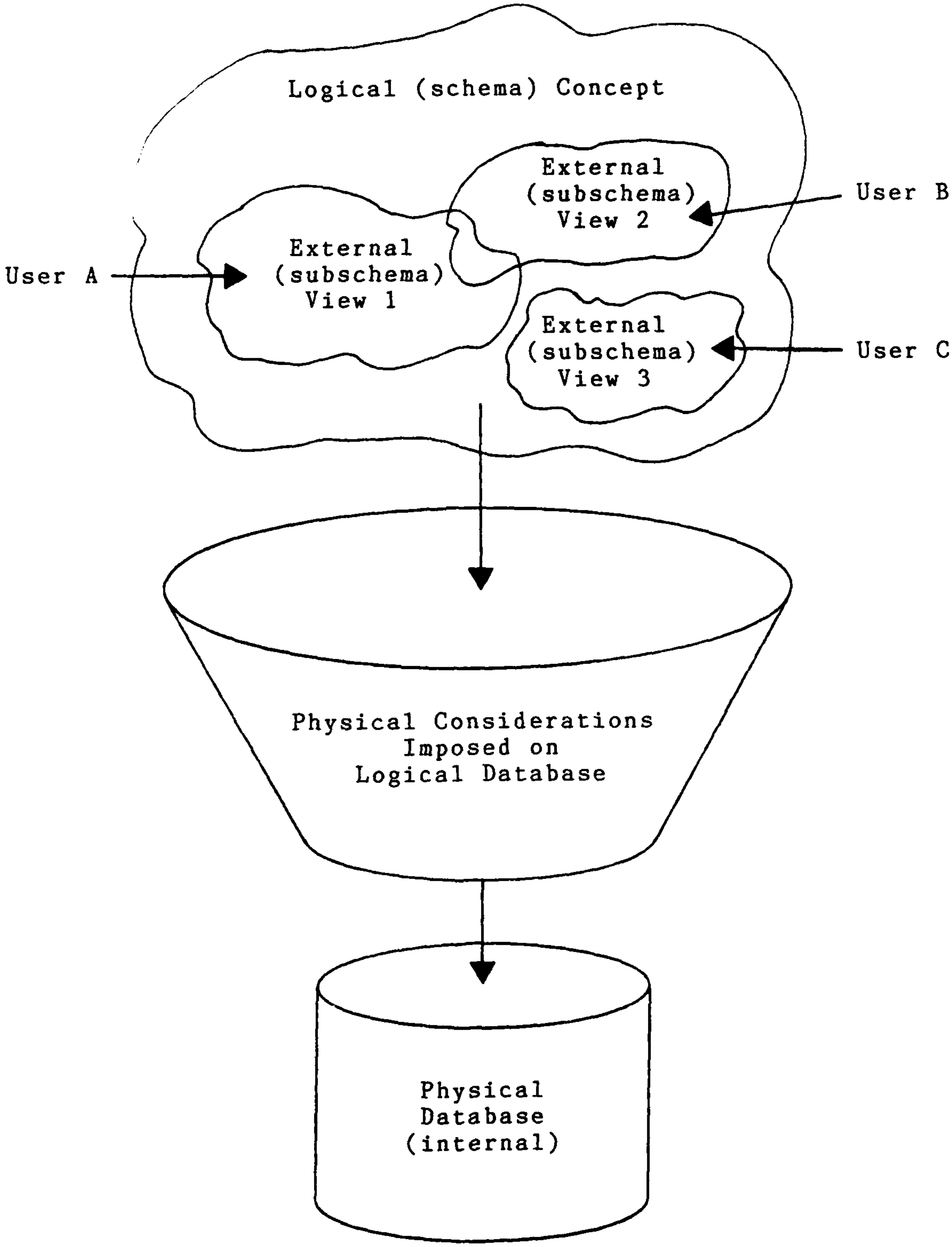


Figure 3.7 Conceptual, External and Internal Views of Data [Cesena 87:p. 5]

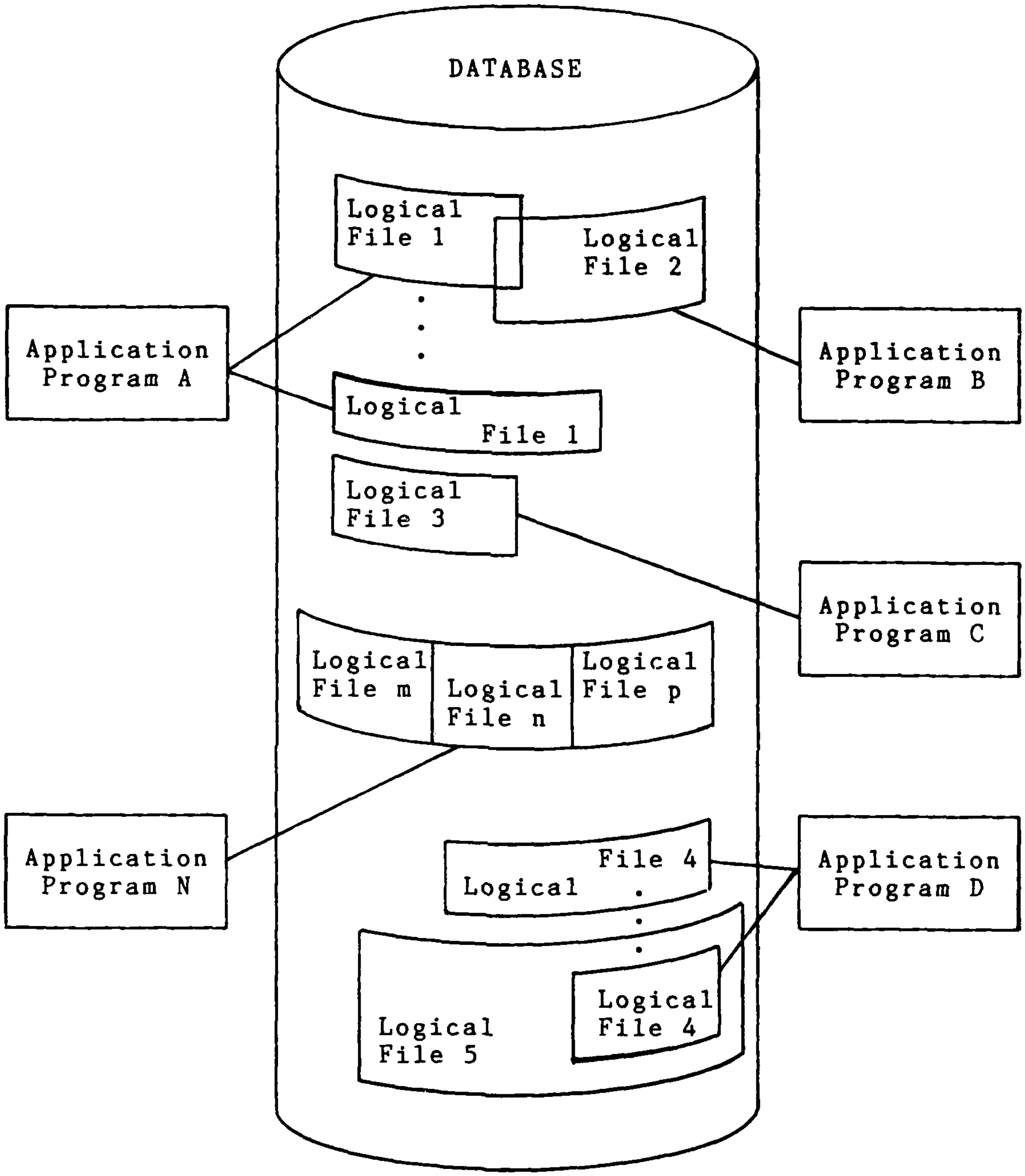


Figure 3.8 Physical Representation of Logical Files
in an Integrated and Shared Database
[Date 86:p. 6]

C. MANAGEMENT

As its name implies a DBMS is a management tool. The DBMS is very important for a MIS and has several components as discussed previously. Kroenke [Kroenke 83:p. 538 ff] describes three aspects of management associated with a DBMS. The first two, management of data base structure and management of database activity are implemented by the DBMS. The third is the management of the DBMS itself. Each of these has application for the CBT system.

1. Management of Database Structure

For database processing to function properly some standardization must exist. This provides a common reference for all users. A data dictionary which contains the names and structures of all records and files is helpful in this regard. Communication between users and DBMS and between users themselves will be improved.

Database systems tend to reduce or eliminate data redundancy. However, some duplication may be required or desired to improve system performance or security. Redundancy which is permitted must be managed to ensure that recurring data is periodically reconciled.

DBMS management must provide for configuration control. Database standards must be enforced. However, a process must be designed for making constructive changes as needed to accommodate a changing DBMS environment. As their requirements change, users should be permitted to suggest appropriate changes to the structure. Information about the DBMS structure and changes made to it must be documented and distributed to users.

2. Management of Database Activity

Data ownership is an important part of database activity. Who owns which data? How is data entered, accessed or modified? Who is responsible for the accuracy of data? Management must deal with each of these concerns.

Security must be provided for any classified data which may exist. Additionally, physical security must be provided against theft, loss, fire, etc. Recovery techniques and procedures must be established in anticipation of machine malfunctions, communication failures or incorrect system use.

Database activity must include training for new and existing users. Initially, new users are to be provided with training to use the system correctly. As the system changes, procedures and policies must be modified and existing users informed and retrained if necessary. Management must enforce data activity policy and procedures for the benefit of all users.

3. Management of the DBMS

Effective operation of a DBMS must be planned and controlled. In addition to periodic tuning of the system, provision must be made for maintenance and modification. System use and performance should be evaluated as to how well user requirements are being met. New products and services from industry and advances in technology should be monitored for application to the system to more economically meet user requirements.

D. ADVANTAGES OF DATABASE PROCESSING

A major advantage of database processing is that it can provide a CBT system with centralized control of its operational data. Centralized control allows more information from the same amount of data compared to a typical file system. Data may be more efficiently shared among legitimate users. With database processing, data redundancy may be significantly reduced and data inconsistency avoided thus providing more accurate data. Finally, database standards may be established and applied to an entire organization. With a database, one department or group can better manage the data through specialization and by providing a central point to implement database policies and procedures.

E. DISADVANTAGES OF DATABASE PROCESSING

Database processing has several potential disadvantages. First and foremost is the fact that it can be complex and expensive. High expenses result from the initial cost and additional hardware needed to support the system. Complexity implies high operating overhead which will actually slow down some simple sequential processes. A complex system is more subject to degradation and failure. A system failure may affect most or all contained processes. With a large and complex system, recovery from failure is more difficult. It is also more difficult to provide security for a large and complex system which has many users.

F. SUMMARY

The chapter began with a discussion of data as a CBT resource, which can provide information and knowledge. As a resource, data is of critical importance to CBT in general and the Navy's Maintenance Training Improvement Program (MTIP) as discussed later. CBT students, instructors and managers use data to achieve their specific purposes. Data elements or the database serve as a foundation for the CBT Management Information System. Data is a critical resource of CBT and a DBMS offers the potential to manage it better. Managerial activities are classified as strategic planning, management control and operational control. Decisions required of training managers lie on a continuum between structured and unstructured. To meet these varying managerial requirements, specialized databases can be designed, which are often useful to very few users. DBMS permits necessary information to be obtained from existing databases and can provide a more responsive MIS for all levels of management and operational users.

The chapter concluded with a discussion of the major components of a DBMS and their functions. The success of CBT rests in large measure on the ability to manage and effectively use data. Database management was described as management of data activity, data structure and the DBMS. Finally, several advantages and disadvantages of database processing were presented.

IV. INTEGRATION OF DECISION SYSTEMS AND COMPUTER-BASED TRAINING

A. DECISION SYSTEMS

The decision-oriented approach to information systems attempts to identify the full range of alternatives and resources available to a decision-maker. Two types of decision systems will be considered as applicable to Computer-Based Training (CBT). The first is a Decision Support System (DSS) which <u>supports</u> decisions. The second is an Expert System which <u>makes</u> decisions. These systems may be integrated for certain applications or employed independently. [Turban 85:p. 141] In either case, the decision action to be taken is usually left to the decision-maker.

Mason [Mason 69:p. 81] directs attention to an important question. Namely, what is the optimal point of articulation or juncture between an information system and the decision-maker? That is, what are the roles of the information system and the decision-maker? Where does the information system begin and leave off and the decision-maker take over?

Figure 4.1 illustrates three possible points of articulation which are represented by Database Management System (DBMS), Decision Support System (DSS) and Expert System. In Figure 4.1, decision-making is presented as a sequence of events culminating in a course of action based on a decision being made. The sequence of activities is summarized as follows:

1. Source--origin of data
2. Data--used to provide information
3. Inferences and Predictions--based on information
4. Value and Choice--apply subjective criteria and ratings
5. Action--make decision and proceed with course of action

Identifying and defining these activities is key to designing an information system.

Figure 4.1a represents a DBMS which is described in Chapter III. The information system receives, classifies and stores data from which a decision-maker may draw information. The information system is designed to contain all the data necessary to provide information for the pertinent decision-making application. The database structure emphasizes economy with data duplication, inconsistency and omission minimized and superfluous data purged regularly to meet system objectives. This configuration presents facts and the decision-maker is left to determine "meaning." This design is best suited for managerial control situations where decisions are mostly objective and structured. Policies and procedures tend to be explicit and well established administratively. In CBT, it is this part of the system which provides scheduled

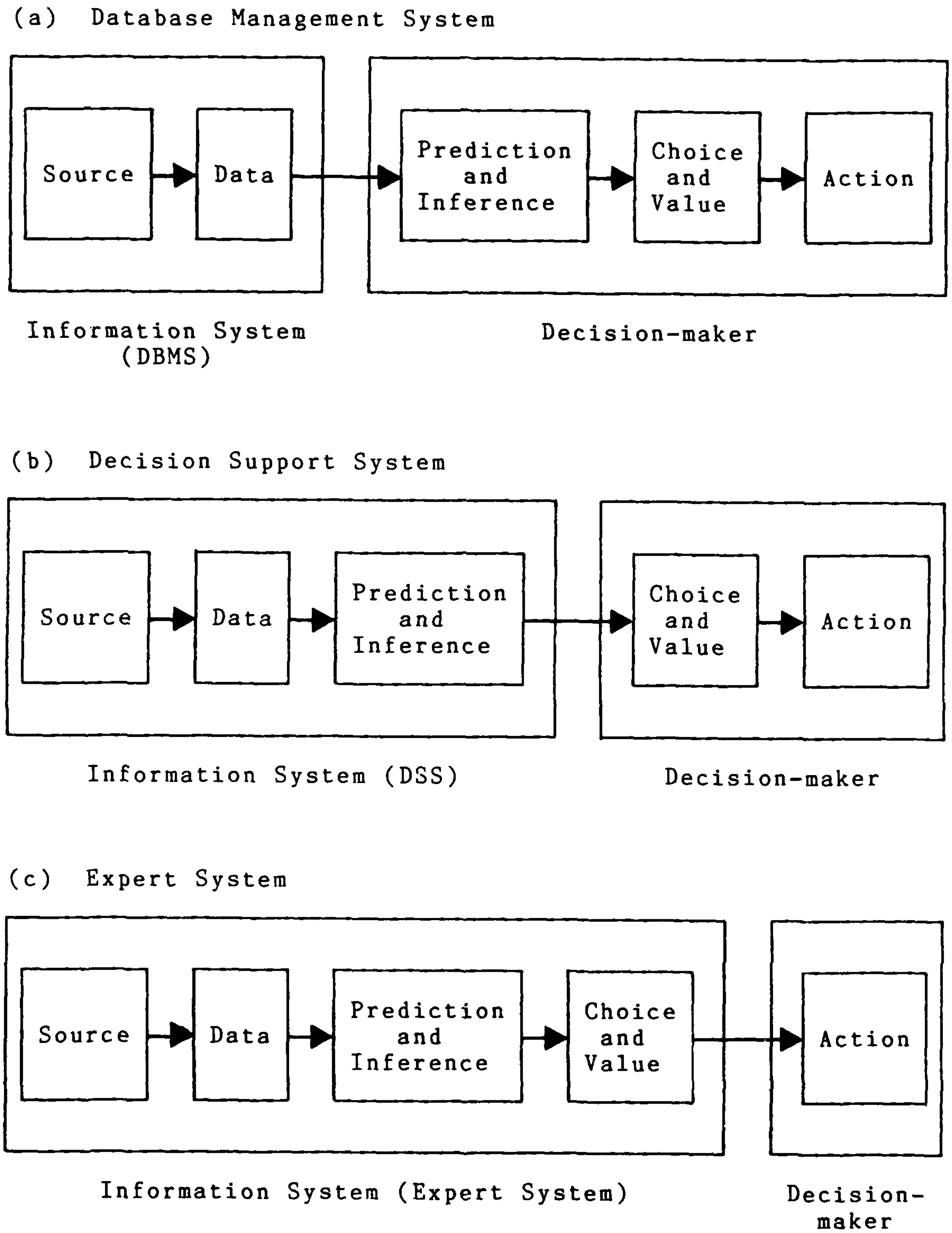


Figure 4.1 Information System and Decision-maker Relationship [Mason 69:pp. 82-86]

reports such as class lists, student schedules and other routine reports.

An information system may extend beyond the activities of pure data collection, storage and retrieval to include the drawing of inferences and making predictions which are relevant for decision-making. This type of information system is a DSS, illustrated in Figure 4.1b. This process assumes certain relationships which are built into the system. An example is simulation models. The decision-maker is permitted to inquire "what if?" certain actions are taken based on assumptions which are considered valid. The system then provides results for all desired inputs based on the simulation model. The system does not evaluate outcomes and the decision-maker is left to assess outcomes and choose a preferred course of action. The next section provides a discussion of the major components of a DSS. An example from CBT, is the evaluation of an increase in course content. How does the change affect student schedules? Are the required resources available when needed? If course prerequisites change how will student loading change?

A further evolution of the information system is an Expert System as pictured in Figure 4.1c. Such a system incorporates an organization's value system and criteria for choice. The design can be referred to as a decision-making system. The system will make a decision and the decision-maker then has an opportunity to reject the decision, accept as is, or accept with modification and then begin a course of action. As its name implies, this process attempts to mimic the behavior of experts. The system incorporates the algorithms of experts to provide the best or optimal solution in a particular area of expertise. Expert systems are discussed in more detail later in Chapter V.

As the information system develops through the phases discussed above, assumptions become intrinsic to the system. These assumptions may become "hidden" to the decision-maker. The underlying assumptions must, however, be in accord with the best judgment of the decision-maker for the information system to become a valuable management tool. Assumptions must be accurate and regularly updated. The decision-maker must develop confidence in the system for it to be employed effectively.

B. CAPABILITIES OF A DECISION SUPPORT SYSTEM

DSS is not merely an evolutionary advancement of EDP and DBMS. It is a class of information system which draws on EDP and DBMS but certainly will not replace either. DSS requires a new combination of information systems technology to satisfy new requirements. The objective is to further improve the decision-making process. [Sprague 80:pp. 10-12] In designing a DSS, the components of the system must be identified and their interface specified. Three prime capabilities are crucial in a DSS. These capabilities are provided by the data management, dialogue management and model management subsystems. [Sprague 80:p. 29]

1. Data Management

A collection of data maintained by a training center for planning, control, training and administration is its database (see Chapter III for further discussion). Sprague and Carlson [Sprague 82:pp. 223-225] suggest that database management is important to DSS for two reasons. First, a database and associated DBMS are needed as a prerequisite to building a DSS because building a DSS without them would be very difficult. They are basic building blocks for a DSS. The reasons for having a database prior to building a DSS may be summarized as follows:

1. Simplifies collection and maintenance of data used by a DSS
2. Limits the functions and users that a DSS must support
3. Simplifies DSS design
4. Reduces potential conflicting performance and security requirements
5. Increases the opportunity for sharing data within a DSS while reducing data redundancy

Having a database prior to building a DSS can reduce the cost of building a DSS while improving the accuracy of the data used in a DSS.

Secondly, data management is a major capability required of a DSS. Data management supports the memory requirements of a DSS. Data for DSS use is stored in databases. Data management provides workspace for intermediate results and provides libraries for saving workspaces. Data management links related data, reminds decision-makers of operations to be performed and of data that should be considered.

Data management includes the ability to reduce or abstract desired information from large amounts of data. For example, in evaluating a course of instruction or a training session, a training manager may want to review the prior training of a group of students who completed the course in question. With data reduction, he should be able to obtain the required information without going through each student record.

DSS should provide varying levels of detail. A manager on the staff of the Chief of Naval Education and Training (CNET) may need information about how Aviation Machinist's Mate (AD) students have been graded over the past year. On the other hand, an instructor may wish to know how a particular class of AD's has done on tests during an ongoing course.

2. Dialogue Management

Dialogue is the interface between the decision-maker and the DSS. It is interactive and determines the user friendliness of a DSS. Dialogue management frequently includes the largest percentage of computer code in a DSS and is most often modified [Sprague 82:p. 217]. Dialogue management provides and manages communication between the decision-maker and a DSS. The form of communication often includes graphics in addition to text.

There are several dialogue styles which may be found in a DSS. A common form is the question and answer dialogue. The DSS presents the user with a question, the user answers the question and the session continues until the DSS produces the answer to support decision-making. These dialogues are most helpful to inexperienced or infrequent users who are not familiar with the DSS.

Another dialogue style is that of command language. Certain commands invoke DSS functions. For example, a CBT manager may enter a command such as PLOT LEARNING RATE and obtain a plot showing a student or class learning rate for all training course modules completed or in progress.

A third common dialogue style is the menu. The user is presented with a number of alternatives from which to choose. Selection is made with a keyboard or another input device such as a mouse or light pen. There are also very limited applications of making a selection by touch-screen or voice instruction.

It is very likely that a dialogue management component will mix or combine more than one dialogue style in any DSS. The objective is to keep the DSS compatible with the needs of the decision-maker. The user may actually be able to choose a style of communication to suit his preference. [Sprague 82:pp. 199-205]

3. Model Management

It is the model subsystem that gives decision-makers the opportunity to analyze a problem fully by developing and comparing alternative solutions. Decision models may be embedded in the DSS with the database capability as the integration and communication mechanism between them. The dialogue subsystem gives users direct control over the operation and manipulation of models. This link provides the ability for true interactive modeling.

To serve DSS needs, the model subsystem must support decision-making activities such as projection, deduction, creation and comparison of alternatives, optimization and simulation. To provide these capabilities, a library of models comprising a model base must be established. The model base may be large or small and includes permanent models, ad hoc models, user-built or commercially obtained, "off-the-shelf" models. Models are included for operational, analytical and strategic decision support. Some models are used as "building blocks" to support the construction of other models.

The comprehensive set of models required for decision support has led to the development of a Model Base Management System (MBMS). There is a pervasive analogy between the database with its DBMS and the model base with its MBMS. The MBMS facilitates several general functions which are very important:

1. Generate--create new models quickly and easily; use model "building blocks"
2. Update--change data in a model without restructuring the model
3. Restructure--redefine model in response to changes in the modeled environment
4. Catalog--categorize and maintain a wide range of models supporting all levels of management
5. Integrate--access and link appropriate models
6. Report--provide information for desired decision support

Through the dialogue component, the decision-maker has the ability to interrupt the running of a model, run model segments and change sequence or parameters. Model management ensures that models draw inputs and parameter values from the database or databases and returns output to the applicable database(s). This promotes accuracy and consistency in model generated output for decision support. [Sprague 80:pp. 22-24, 82:pp. 257-272]

C. PERFORMANCE OBJECTIVES

Sprague [Sprague 80:pp. 18-20] delineates several DSS performance requirements. No particular DSS may be able to meet all requirements. DSS performance depends on the task, the organizational environment and the decision-makers involved.

A DSS should provide support primarily for semi-structured and unstructured decisions. For these decisions, databases and traditional information systems may be inadequate. DSS are designed to provide support for these kinds of problems.

A DSS should provide support for managers at all levels. CBT managers from CNET to course instructors and training managers should find support from DSS to solve problems in their professional realm.

A DSS should support decisions which are interdependent as well as those which are independent. Many decisions must be made in consonance with other decisions made by others or groups. The following decision types should be considered:

1. Independent--a decision-maker has full responsibility and authority to make a decision

2. Sequential--a decision-maker makes a decision or part of a decision which is then passed on to another decision-maker

3. Pooled--a decision results from negotiation and interaction among decision-makers (A Group Decision Support System (GDSS) is a specialized DSS)

A DSS should support all phases of the decision-making process. Herbert Simon [Sprague 80:p. 19] characterized three main steps in the decision-making process as intelligence, design and choice. Intelligence is monitoring or searching the environment for conditions calling for decisions. Raw data is gathered, processed and examined for clues that may identify problems. Design is creating, developing and analyzing potential courses of action. Choice is selecting a course of action and implementing it.

A DSS should support a variety of decision-making processes. Each CBT manager has an individual cognitive style and approach to problem-solving for his specific functional domain. There is no one best decision-making method. A DSS should be process independent and user controlled and directed.

A DSS should be easy to use. It should not further complicate the decision-making procedure. The user must be comfortable with a DSS and develop confidence in it for it to become a valuable and convenient management aid.

D. EXPERT SYSTEMS

Expert Systems may lend considerable aid to the training process as well as its management. Although this technology appears to be in its infancy, there seems to be much potential to significantly improve and enrich the training process and the quality of training provided by CBT.

An Expert System is a Knowledge Base Management System (KBMS) which is particularly useful for dealing with a diagnostic or other interpretative tasks [Mylopoulos 86:p. 4]. Such a system attempts to mimic top human experts and embodies knowledge of a particular limited application area [Turban 85:p. 138]. The role of the Expert System in decision-making is extracted from Figure 4.1 and illustrated in Figure 4.2.

Expert Systems have evolved from earlier Management Information Systems (MIS) and often interact with them. For example, DBMS provide information to Expert Systems in the same fashion as a human expert would use a data source such as a book or library to obtain factual information. Expert Systems may also rely on the model base of a DSS to provide established mathematical and forecasting models to lend support for system decision-making and expertise. [Turban 85:pp. 145-146] However, there are significant differences between a DSS and an Expert System as illustrated in Table 4.1.

According to Bevan and Wetherall [Bevan 87:p. 21], the process of building the knowledge base associated with an Expert System is long and complex but contains very valuable information. Most Expert Systems are designed to be used in a consultative manner by non-experts to perform a task in the narrow area of expertise. In the consultative role, Expert Systems may aid a technician in equipment fault isolation and suggest appropriate corrective action. However, Bevan and Wetherall suggest that the idea of using the same knowledge base in a training role is very attractive.

The Air Force Human Resources Laboratory (AFHRL) has a research program to develop and demonstrate the technology

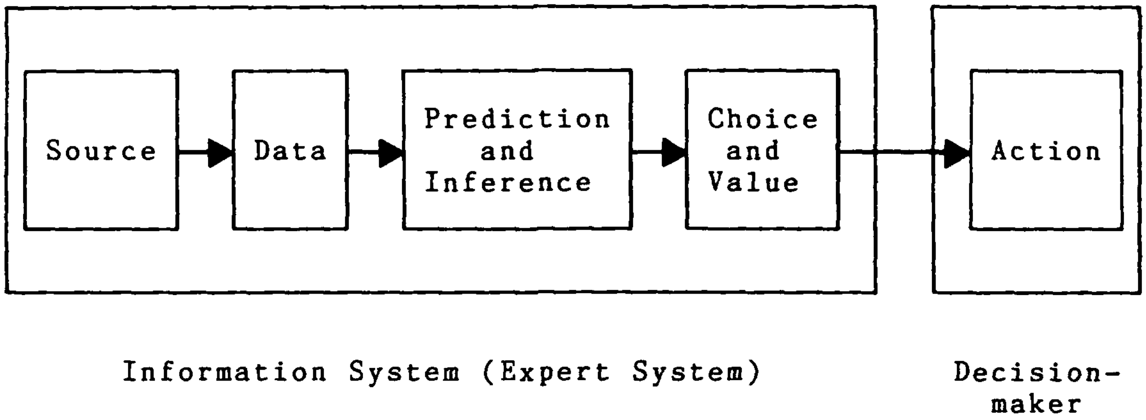


Figure 4.2 Information System and Decision-maker Relationship for Expert System [Mason 69:p. 86]

for an Intelligent Maintenance Advisor. The Maintenance Advisor would serve as an "expert" for both consultative and training roles. As envisioned, the Advisor would be a skill integrator by using and capturing the corporate memory of skilled technicians. This knowledge would be used in turn to provide trouble-shooting training for novice technicians. [Richardson 86:pp. 47-50]

1. Varieties of Knowledge

Knowledge may be classified in several ways. As illustrated in Chapter III, knowledge may be comprised of the complimentary ingredients of formal training and prior experience. As a result of formal study, knowledge is gained which is composed of definitions, axioms and l ws. Successful trainees emerge from courses with a firm grasp of the terms, procedures and laws which constitute the formal

TABLE 4.1 DIFFERENCES BETWEEN DSS AND EXPERT SYSTEMS
[Turban 85:p. 141]

	DSS	Expert System
Objective:	Assist human	Replicate (mimic) human
Who makes the decision?	Human chooses from options	Human considers a recommendation
Major orientation:	Decision making	Transfer of expertise
Problem area:	Complex, wide, integrated	Narrow domain
Query direction:	Human queries system	System leads human
Database:	Factual knowledge	Procedural and factual knowledge

theories and accepted principles of their training discipline. This type of "head" knowledge can readily be described but has yet to be applied in a practical way. [Harmon 85:p. 30]

This kind of knowledge is generally well-structured and is amenabie to the formulation of general principles for correct behavior. Spiro states that it is this knowledge domain in which past educational practice has had the most success and cognitive psychology and artificial intelligence have made their greatest advances. [Spiro 87:p. 286]

Knowledge may also be compiled by personal experience or by learning from a mentor. The student learns to rely on rules-of-thumb to perform specified tasks or to solve simple problems. This type of knowledge is referred to as heuristics. [Harmon 85:p. 31] Knowledge of this type may be relatively ill-structured. It may be difficult to define a single set of attributes for all cases. Interactions between various features in complex problems proliferate and may be highly dependent on one another. General principles are insufficient to solve individual cases satisfactorily, resulting in problems which are very difficult to decipher and resolve. [Spiro 87:p. 286]

2. Expertise

How do experts solve problems? They use expertise gained about a subject to solve problems in that realm. An expert is an individual who is recognized as being able to solve a particular type of problem that most other people cannot solve as efficiently or effectively. Experts are able to perform successfully because they have acquired a large amount of domain-specific knowledge--expertise.

Expertise may be gained entirely from experience or wholly from education without the benefit of formal training. However, most experts, including pilots, doctors, accountants and technicians, begin by studying their specialty in school. They learn principles and theories which are considered as basic to their profession. They continue by gaining experience through working in their professions and perhaps, working with a mentor. In this way, they gain expertise and may become regarded as expert in their profession. [Harmon 85:pp. 31-32]

E. EXPERT SYSTEMS AND COMPUTER-BASED TRAINING

Experience-Consolidation system is a term which describes an Expert System intended primarily for training. These systems "telescope" aspects of the process by which practical field experience leads to the acquisition of expertise. Thus an expert methodology is scrutinized to determine and then teach its essential characteristics. These systems attempt to teach intuition and give people the ability to think correctly for themselves without explicit guidelines in particular realms. Experience-Consolidation systems attempt to shorten the time required for the would-be technician to gain experience from years to months or days. These systems attempt to teach what has not been taught conventionally and has traditionally been left for "on-job-training" (OJT) or as a skill to be gained through "field experience." [Spiro 87:p. 285]

Experience-Consolidation systems most closely resemble the Computer-Aided Instruction (CAI) form of simulation. Simulation does require active participation by students and promotes learning by doing. However, there are significant differences between simulation and Experience-Consolidation systems. Simulation usually does not convey all the multivariate attributes of a complex case. It is not concerned with the effective acquisition of multi-patterned information. And, simulation cannot rapidly present a large number of cases for consideration. Experience-Consolidation systems and simulation may be used to complement each other in a training environment. [Spiro 87:p. 291]

1. Implementation

As noted above, the idea of using Expert Systems in a tutoring role is very attractive. Is this possible? Is it practical? Expert Systems for training or Experience-Consolidation systems attempt to shorten considerably the time required to acquire large amounts of experience and expertise and then pass these on to trainees. The process must safeguard the essential characteristics of the expertise so that it remains relevant.

A dilemma is obvious. In the real world, these essential characteristics themselves hinder shortening of expertise acquisition time. First, actual cases occur over long duration. Also, the amount of information to be gleaned over time is large and by definition, ill-structured. The information cannot be arranged (chunked) in hierarchical fashion and there is simply too much to remember. Finally, cases happen in haphazard order without regard to instructionally useful arrangement. [Spiro 87:p. 287]

Spiro [Spiro 87:p. 287 ff] discusses each of these problems and suggests ways in which they may be overcome. To use this technology successfully, a training program must solve the challenges presented by these difficulties. The following sections present several of these ideas.

a. The Problem of Time

The experience needed to gain acceptable expertise may last for years. This problem is addressed by gathering many cases and extracting from them the most significant multivariate information needed to fully characterize a case's environment. For the Navy Maintenance Training Improvement Program (MTIP), this could be accomplished by gathering many skilled technicians, regarded as experts in the applicable field, and conducting interviews or making observations. Why are exhaustive representations important? The need is to richly and fully present the context in which the decision factors occur. A principle of Experience-Consolidation systems is that in ill-structured domains, contexts are taught to teach concepts. Situations (cases) are thus presented from many points of view.

b. The Problem of Information Overload

This problem is the most difficult. The challenge is met by using specially designed graphic aids which are tailored to simultaneously present complete sets of complexly entangled patterns at a glance. This method taps into everyone's finely developed perceptual processing system. Experimental psychologists have established that humans have an extraordinary ability to remember many briefly presented visual scenes. The message for CBT is clear. High quality graphics capability is essential for this type of training. This powerful ability of human thought is employed to encode the manifold features of ill-structured conceptual situations. These situations can only be understood and comprehended by simultaneous appreciation of multiple, partially overlapping interrelationships.

This perceptual solution to the information overload and memory problem provides an optimal representation for conveying pattern and context information. A perceptual view comprehends many things juxtaposed. In a short time, many coexistent parts are viewed in one field of vision. Consider all the information absorbed simultaneously by viewing the image of a face or a landscape. People readily perform on stored perceptual information to detect patterns of resemblance and dissimilarity. Experience-Consolidation systems use the computer to tap into a powerful processing system of humans. This system is well suited to processing large amounts of intricately entangled information in ill-structured knowledge domains.

c. The Problem of Arrangement

An arrangement system must be designed to maximize the retention of robust case information in order to highlight case information which may produce application difficulties. The system must be able to distinguish cases which appear similar but produce different outcomes and those which seem unrelated but produce similar outcomes. An arrangement system must also classify cases so that many complex resemblance patterns within the same outcome category can be learned. The power, speed and flexibility of a computer are needed to make a functional system. Highlighting multiple connections and similarities between cases, permits de-emphasis of the retrieval of precompiled diagnostics in favor of diagnostic building, to fit the needs of a given situation. If training is to transfer expertise, the flexibility of knowledge representation is crucial.

2. <u>An Intelligent Computer-Aided Instruction System Model</u>

An Expert System which is employed for training may be referred to as an Intelligent Computer-Aided Instruction (ICAI) system. According to Bevan and Wetherall [Bevan 87:p. 21], with this technique, knowledge bases are used to represent the teaching domain and to govern the operation of the instructional system. There are two advantages to this approach:

1. The operational characteristics of the system may be easily modified by using a rule base to govern the operation of the instruction system.

2. Isolation of domain dependent rules from instructional rules permits the creation of a generalized ICAI system which can be used for a variety of teaching domains.

This is seen as a way to capture the knowledge base of an Expert System for training and provides a means whereby operational staff can observe the performance of an Expert System. Such a system has been created and is known as TUTOR.

A model of the TUTOR System is illustrated in Figure 4.3. In simplified terms, the system makes a current assessment of a student's ability and knowledge from the Student Model. The Teaching Generator then decides what kind of interaction (exposition or problem to answer, for example) to give the trainee and selects a particular topic to present. The Administrator presents the situation to the student through the Natural Language Interface and to the Domain Expert System for the correct solution. Finally, each interaction with the trainee is recorded in the Student Model, so that the Teaching Generator may choose what to do next. Note that the TUTOR is an Expert System in its own right. Its major components are more fully described in the following paragraphs. [Bevan 87:p. 22-23]

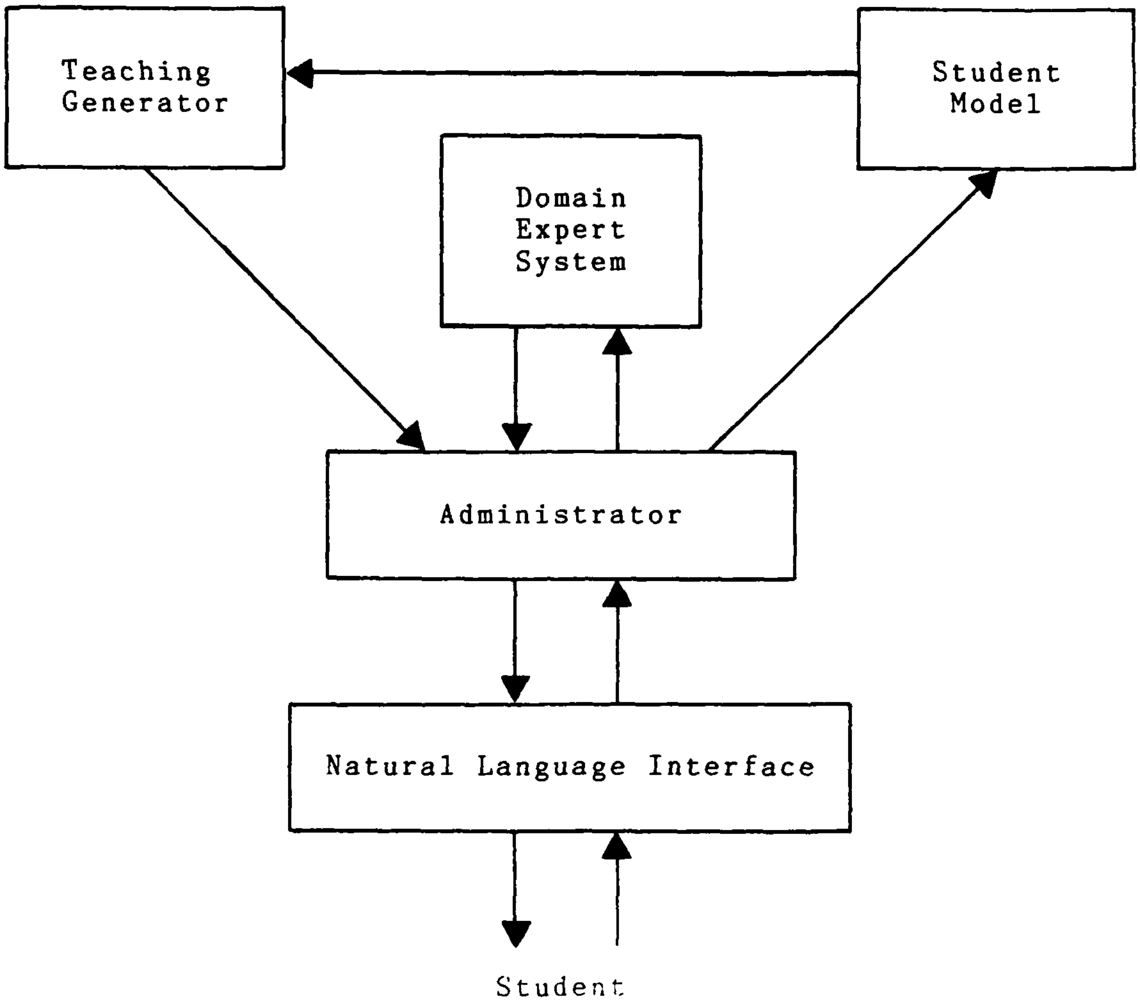


Figure 4.3 Intelligent Computer-Aided Instruction System Model (TUTOR) [Bevan 87:p. 23]

a. Administrator

The Administrator serves as the nerve center of the system. It provides general management and control over system resources. It serves as the primary connection and main interface between components of the system.

b. Domain Expert System

This component contains the domain specific rules as they would appear in a consultative Expert System. It provides information to check student answers and responses. An explanation facility should be included to provide trainees with the reasons for correct answers or responses.

c. Natural Language Interface

Compared to a consultative system, this component is more important for the training system. A teaching system will require more two way communication between student and machine. Sometimes the student will be controlling the dialogue such as when seeking further explanation about subject material, at other times the system will be presenting material and controlling the dialogue. A fairly sophisticated Natural Language Interface is needed to give a wide range of users freedom in expressing their responses or answers to problems.

Another requirement of the Natural Language Interface in a generalized system is that it be able to modify the vocabulary when the subject domain is changed. This is important for technical training subjects and to accommodate unique military terms.

The U. S. Navy has sponsored research to develop an "intelligent" interface to CBT. The interface would be capable of responding to questions and answers in free form.

Humans could communicate with computers in English without having to learn a special computer language. Furthermore, the knowledge base used for response generation could be automatically expanded as trainees and course administrators interact with the system. [Bryant 88:pp. 199-206]

d. Student Model

The Student Model maintains a record of a student's knowledge of the subject domain. It may contain information about a student's preferred learning strategy and level of expertise. Levels of expertise may be categorized into several classes such as novice, competent but needing revision, skilled or expert, for example.

e. Teaching Generator

The role of this component is similar to that of a human tutor. It provides initial, corrective and remedial training on individual topics in the syllabus. To determine trainee comprehension, it generates problems for the student to solve consistent with the student model and the curriculum material as presented. It determines the nature of problems for consideration and the method of presentation. [Bevan 87:pp. 22-25]

F. SUMMARY

The chapter began with a discussion of DSS and Expert System applications to training. The major subsystems of a DSS--data management, dialogue management and model management--were described. Several performance objectives were discussed. A DSS must be easy to use, promote user confidence and not further complicate decision-making. An effective DSS will accommodate the needs of all levels of training management. Also, a DSS should provide assistance with both independent and interdependent decisions which lead to effective and efficient use of training resources.

This chapter portrayed the Expert System as an powerful vehicle for training. Expert Systems have traditionally been relied on in a consultative manner to provide solutions for specific problems in the realm of expertise. The knowledge encapsulated by these systems makes them attractive for technical training. However, several major difficulties are apparent. The problems of time, information overload and arrangement are presented.

Nevertheless, Expert Systems have been applied to training programs. A model of one such implementation, TUTOR, is illustrated. The system itself functions as an Expert System. It has five major components--Administrator, Domain Expert System, Natural Language Interface, Student Model and Teaching Generator. The roles and functions of each component are discussed. Although in its infancy, this technology may provide significant CBT potential with specific application to the Maintenance Training Improvement Program (MTIP) as discussed in the following chapter.

V. COMPUTER-BASED TRAINING APPLIED TO THE MAINTENANCE TRAINING IMPROVEMENT PROGRAM

A. INTRODUCTION

As described in previous chapters, the U. S. Navy has had a long association with various aspects of Computer-Based Training (CBT). In recent years, the Maintenance Training Improvement Program (MTIP) has become very important in the training of naval aviation maintenance technicians. For the MTIP, most data for learning and student information is computerized.

MTIP is a training management system and a method of inservice training. The program is a command responsibility which attempts to identify maintenance performance deficiencies at the command, work center and individual technician levels. As deficiencies are identified, refresher or remedial training is conducted to provide correct technical knowledge and to improve job skills. [NAMP 86:pp. 12-7 and 12-8; CNAP 86:p. 1]

The primary means used to identify knowledge and skill deficiencies is through a testing program which includes standardized question and answer banks from which computerized tests are generated. The tests are intended to examine the knowledge and skill of maintenance technicians compared to their peers and standards established for each occupational specialty or rating. Test questions are to be prepared by Subject Matter Experts (SME) and require periodic validation. [CNAP 86:p. 1]

MTIP has been widely implemented and provides units with some flexibility to direct their own inservice training program and compare the outcomes to established standards. Although use is widespread, acceptance has been less than desired. The program is seen as administratively burdensome and not producing intended results, such as, significantly improved maintenance technician knowledge and skill levels. It is the thrust of this thesis that application of CBT technology, as discussed in previous chapters, may provide a means to improve the current MTIP and lead to future enhancements.

B. COMPUTER-BASED TRAINING TECHNOLOGY FOR MTIP

CBT technology involves much more than the physical components that are visible and obvious. It encompasses methods, techniques and procedures that result from tradition, regulations, vision and available resources. Technology may be divided into "hard" components (physical devices) and "soft" components (methodologies). While those components may be identified individually, they are closely intertwined in actual technology applications. When evaluating a training system, the interaction among components must be considered as well as the components themselves. [Kearsley 84:p. 3]

The MTIP is conducted mostly by aviation squadrons, Fleet Readiness/Replacement Aviation Maintenance Personnel (FRAMP) units, Naval Air Maintenance Training Group (NAMTRAGRU) units, Navy Engineering Technical Services (NETS) or Contractor Engineering Technical Services (CETS). This training is primarily passive and relies largely on static media such as printed technical manuals, workbooks and slides. There is also some use of dynamic media. This includes films and video. The use of an interactive media, i.e., a computer, for actual training does not exist in the MTIP. Computers have been used to maintain databases and administrative records. CBT does provide the capability for active learning with computers.

1. Database Management

Chapter III describes why data is a very important resource in a CBT system. It is important because of the information which becomes available to both students and managers. This is certainly true for MTIP and is an area where significant progress could readily be made.

The MTIP has been perceived as producing too much inaccurate, misleading or wrong information. Much of this problem relates to the system development and is discussed later under Instructional Systems Development (ISD). However, an integrated computer-based system could be more responsive to the users. It is now very difficult and time consuming for users to provide corrective input to the existing system.

A Database Manager, similar to a Database Administrator (to use database jargon), should be established for each MTIP database. The Database Manager should have the power to control that database and not merely coordinate or monitor activity. Users should be able to provide change inputs quickly and preferably on-line. The Database Manager should be able to promptly evaluate the inputs and make changes as necessary. Proper evaluation of change recommendations will require the many resources including those of Naval Air Systems Command (NAVAIR), CETS, NETS and occasionally the commercial contractors of the system, aircraft or equipment involved. The Database Manager should be able to determine a proper solution for change recommendations and provide rapid response to a user and alter the database as necessary.

The database must be very large to encompass the scope and depth of all data needed for complete maintenance training for even one type of aircraft. If the database is too limited students quickly learn the "right" answers to particular questions. As this "gouge" is passed to others, the MTIP looses effectiveness. A more advanced system should be able to produce differing questions and answers on the same topic.

The MTIP database could store appropriate lessons or lesson guides for MTIP topics in addition to question and answer banks. It has been difficult to coordinate training with established testing. CBT could improve the interconnection between training and testing materials. The training materials could be generated as they currently are by FRAMP, NAMTRAGRU and squadron personnel and be incorporated into the MTIP databases.

With the right equipment, training could be conducted at the squadron without having to schedule training sessions with another activity. Training could also be conducted on a more individual basis so that entire work centers would not have to be absent for training at the same time. Individualized training has other benefits which are discussed later. Additionally, CBT could better facilitate remedial training sessions at a FRAMP or NAMTRAGRU. This would provide better coordination and improved use of training resources over a manual system.

2. Decision Support

Chapter IV describes the fundamentals of a general Decision Support System (DSS) and provides some specific applications to the CBT environment. DSS are created to provide assistance for semi-structured and unstructured decisions. For the MTIP to be a true Maintenance Training Improvement Program, it must assist the training manager in decision-making to further improve and refine the MTIP.

For example, based on MTIP data, managers should be able to develop student profiles and be able to classify students into desired categories such as novice, apprentice or master technician. A DSS could provide an optimal training plan for each category of trainee. With information of this type, remedial training could be developed to better suit the needs of individual students. This could provide more stability and direction to a training program.

A DSS function can also lead to better resource use. Training resources of several activities are now available to the MTIP. A centralized, responsive system could aid the decision-maker in the most efficient coordination and scheduling of those resources with user need and priority considered appropriately. Additionally, usage data of the various resources would be available to support training managers in decisions about redistribution of existing assets or further development and procurement of new hardware, software or training technology.

A DSS can also serve to give indications of overall MTIP effectiveness. As criteria are incorporated, information on various aspects of effectiveness can be used for evaluation. "What if?" evaluation may be done for squadron, functional wing or type command changes. Appropriate corrective action may be initiated to improve effectiveness.

A DSS as part of the MTIP, must use data which is easily available and obtainable. It must be designed to produce output which is meaningful, timely information, not just data. The DSS must focus on the where, what and when of technical training for the various specialties or ratings. [Ruck 86:pp. 47,54]

3. Expert System

Expert Systems have typically been considered useful for consulting or as advisors. In these roles, the Expert System is relied upon to provide expertise for a specified topic. As described in Chapter IV, the idea of using an Expert System knowledge base for training is very attractive. Attempts have been made to convert or develop effective training tools from consultative Expert Systems. [Clancey 87:pp. 1 ff, Richardson 86:pp. 47-51]

There are several possible uses of Expert Systems for future MTIP development. Expert System may be able to impart expert knowledge to maintenance technicians. This is much more than the information taught by the current MTIP. Expertise can now be gained only through years of job experience, on-job-training (OJT) and study. There is potential for an Expert System to capture an aggregate of existing expertise for various ratings. Using Expert System training, expertise may be transferred to students in days and months instead of years.

Furthermore, an Expert System may raise individualized training, a key concept of the MTIP, to a new level. It can provide unique initial, corrective and remedial training for each student based on the student profile. It can "intelligently" determine trainee comprehension, generate problems for the student and determine the method of presentation. Each trainee receives instruction designed specifically for him. Another feature of an "intelligent" system is that it can respond to a much wider range of communication with humans. It can make a system much more "user friendly." The U. S. Navy has sponsored research to develop an "intelligent" interface to CBT [Bryant 88:pp. 199-206]. Future developments may have application for the MTIP.

CBT offers the possibility of considerably expanding the scope of the current MTIP. The Air Force Human Resources Laboratory (AFHRL) has made an initial effort to develop an Intelligent Maintenance Advisor. The envisioned role of the Advisor is to (1) enable unskilled technicians to perform as if they were skilled ("skill multiplier"), (2) tutor technicians who need further development of their technical skills and (3) work cooperatively with skilled technicians to capture diagnostic insights (expertise) for the benefit of their successors. Such a device retains its training function and also serves as a "skill integrator" to interactively assist the experienced technician with possible solutions to a problem being considered. Finally, this technology could provide the MTIP with an authoring system to create new training knowledge base or modify existing knowledge bases. [Richardson 86:pp. 47-48]

4. Instructional Systems Development

A common methodology for conducting CBT is Instructional Systems Development (ISD). The Commander, Naval Air Force, United States Pacific Fleet, has directed that test questions be generated for MTIP using ISD [CNAP 86:p. 1]. The most important goal of ISD is to provide performance oriented training.

CBT is the most feasible method to support an extensive ISD framework for a large scale training program like MTIP. The performance oriented philosophy differs from the traditional curriculum approach. ISD focus on providing consistent training to improve future job performance while the traditional approach centers on the training of topics developed individually each time the training is offered, without regard to how the training will be used. Table 5.1 illustrates the difference between MTIP using the ISD and traditional approaches to instruction. [Kearsley 84:pp. 83-84]

Another characteristic of ISD applicable to MTIP, is that empirical evaluation is an integral part of the training program. In the course of training, the user and the managers may detect deficiencies in the program. Also, the needs of the user or the Navy may change with time. A computer-based training program may be altered and customized to meet the needs of the Navy or users. Corrections may be implemented promptly. Service-wide alterations may be incorporated rapidly with good configuration control and high confidence of standardization where needed.

A third characteristic of ISD is the attempt to define optimal strategies, media and sequencing for selected training activities. While MTIP does seek to find the optimal strategy to conduct training, the use of limited media and inability to optimally control sequencing also apply. CBT can coordinate the availability of many media--print, slides, video, computers, simulators, embedded training and expert systems--to illustrate a range of possibilities. [Kearsley 84:p. 83]

ISD may be applied to both computerized and non-computerized training. MTIP has employed the most basic features of CBT. Computerized impact has primarily been along the lines of Computer Managed Instruction (CMI) to meet administrative needs. Future developments and enhancements for MTIP will likely involve more application of CBT and are discussed later. The large size of MTIP, potential high cost for further evaluation and maturation, and the commitment to ISD suggest a phased approach with increased CBT for MTIP.

TABLE 5.1 COMPARISON OF MTIP WITH ISD AND TRADITIONAL APPROACHES TO INSTRUCTION [Kearsley 84:p. 84]

MTIP using ISD	Traditional
Content based upon performance	Content based upon topics to covered
Instructional objectives are explicitly stated	Instructional objectives are implicit
Content is developed by multidisciplinary team	Content is developed primarily by instructor
Evaluation is part of development process	Evaluation occurs after training is implemented
Media, strategies and sequencing are analytically derived	Media, strategies and sequencing are intuitively selected
Materials take into account student capabilities and differences	Materials are designed for ideal or average student
Development process and implementation are consistent and reliable across individuals	Development process and implementation are idiosyncratic and vary with instructor

ISD has been most widely and thoroughly applied in the military training environment. This is because of the long lead time and expense required for the most effective training program and the severe consequences of inadequate training programs. Table 5.2 depicts the benefits to MTIP of the ISD methodology compared to traditionally developed instruction. [Kearsley 84:pp. 87-88]

TABLE 5.2 BENEFITS FOR MTIP FROM ISD COMPARED TO TRADITIONALLY DEVELOPED INSTRUCTION
[Kearsley 84:p.88]

1. Training closely matches job requirements and student needs
2. Training takes significantly less time to complete
3. Training is highly consistent across different occasions and instructors
4. Training can meet a wide range of variation in student entry levels and abilities
5. Improved confidence, morale and satisfaction on the part of students

ISD has been described as consisting of five major phases which are illustrated in Figure 5.1. Each phase may include several steps depending upon the application. [Kearsley 84:pp. 85-86, Logan 82:pp. 6-12] These phases are relevant to MTIP development and enhancement.

a. Analysis

In the Analysis phase, needs are assessed with respect to a performance problem or a new requirement. The nature and scope of the training required are identified. Is MTIP training the appropriate solution? Perhaps a personnel, organizational, procedural or job aid solution is needed. Also, available resources and the time and schedule constraints for a prospective MTIP must be identified.

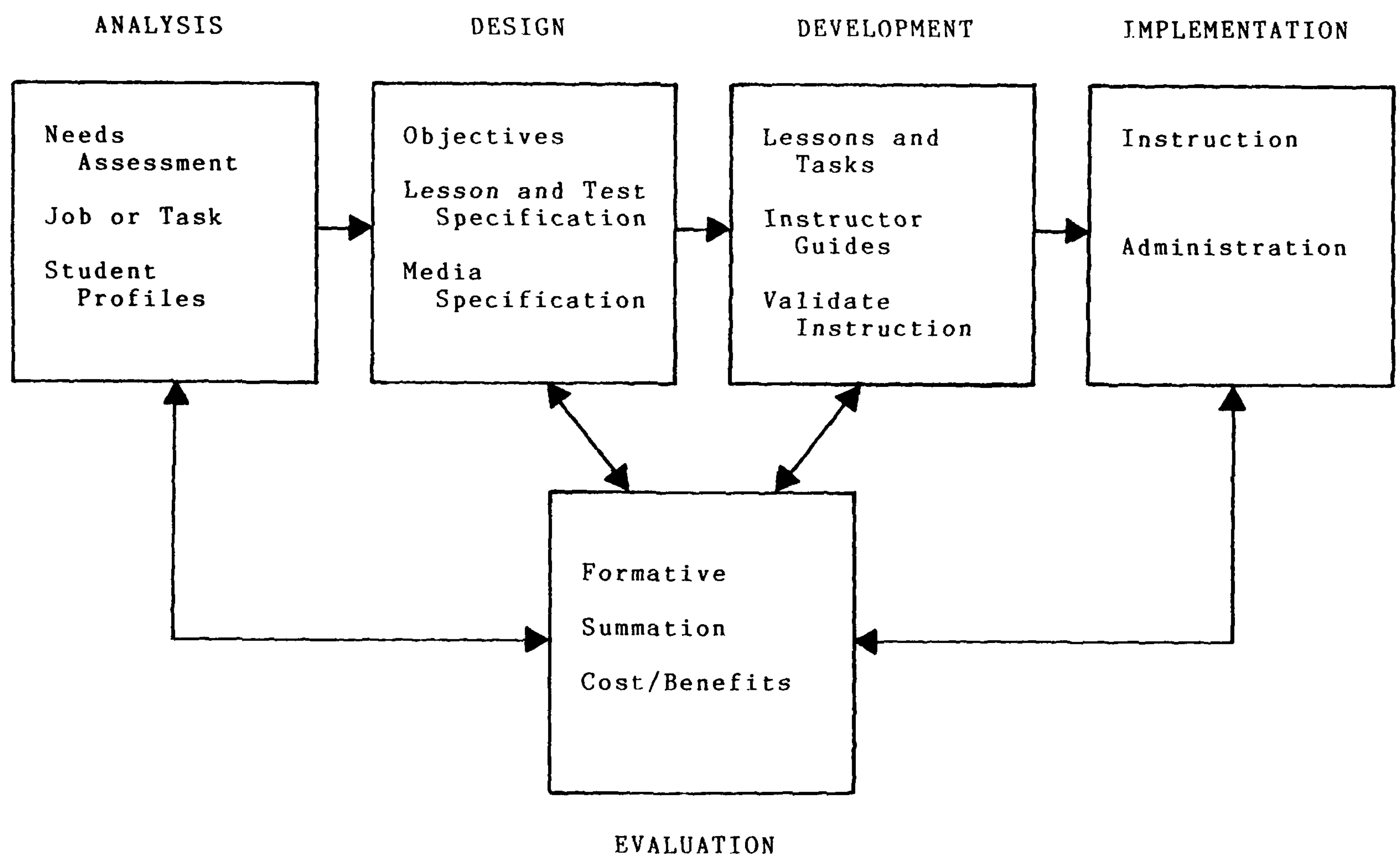


Figure 5.1 Major Phases of ISD Applicable to MTIP
[Kearsley 84:p. 85, Logan 82:p. 8]

Additionally, the jobs or tasks to be taught must be identified by the functions to be performed. Finally, students to be trained should be analyzed to determine aptitudes, motivation, reading ability and prior job knowledge and experience. Can individual differences be accommodated by MTIP training?

b. Design

The Design phase is concerned with defining instructional objectives, specifying lessons and tests and selecting the applicable media. Instructional strategies and sequencing based on aircraft systems are determined. In this phase the nature of the training can be specified.

c. Development

Lessons and tests are written based on input from aircraft maintenance experts. This involves technical writing and the production of manuals, slides, video or CBT. Also, prepared are instructor guides and materials for administration of MTIP such as training plans, evaluation forms and student records.

d. Implementation

Implementation is the delivery and management of training. Instructors and staff must be trained to use CBT such as the MTIP. Facilities are readied while time and space are allocated for training. Training is conducted, students learn, take tests and receive remedial training as necessary. Records are kept and data is collected, distributed and stored.

e. Evaluation

As shown in Figure 5.1, Evaluation occurs throughout all phases of ISD. Evaluation provides feedback, control and regulation for the entire process. CBT can provide this capability. Initially, evaluation is made to improve instruction (formative). Later, judgments are made about the effectiveness of training (summation). As Evaluation controls the ISD process, it may also trigger the beginning of a new process or the termination of ISD for a particular environment. [Kearsley 84:pp. 85-87, Logan 82:pp. 6-13]

C. SUMMARY

This chapter portrayed application of Computer-Based Training (CBT) to both the present and future Maintenance Training Improvement Program (MTIP). The present MTIP was described briefly. Several proposals were made to improve the current MTIP through better database management techniques. Progressive database management provides a much more responsive system and one that is more in tune with the needs of user operators.

Decision support available in a CBT system, could provide MTIP managers and users with much more suitable information with which to manage. With this support, MTIP resources could be better used to meet training needs. With efficient resource use and better management information readily available, MTIP effectiveness will certainly improve.

Expert Systems were described as a means of significantly altering the training process itself. It may become possible to teach experience as well as information. Expert Systems may permit more integration of actual maintenance and the training to do maintenance. CBT has great potential to provide enhancements to the current MTIP and promote progressive future developments.

Finally, Instructional Systems Development (ISD) was presented as the preferred method of MTIP with CBT implementation. In fact, current policy directs that test questions for current MTIP applications be generated with ISD. Some of the characteristics of ISD are described and the five major phases are illustrated. ISD was depicted as being performance oriented and several of the major benefits for MTIP are portrayed.

VI. CONCLUSIONS AND RECOMMENDATIONS

The installation of computers into the classroom alone does not result in Computer-Based Training (CBT). Rather, CBT draws from both educational and computer technology to add new dimension to training. CBT has been implemented for a number of reasons. These reasons may generally be categorized as those which reduce training costs and/or those which improve training effectiveness. CBT has not been a panacea for all training environments but has worked well in many military training centers.

The Maintenance Training Improvement Program (MTIP) is already a computer-based training program which can benefit substantially from increased employment of CBT! MTIP can be impacted by CBT in the two areas of database processing and management and, secondly, decision systems.

A. DATABASE PROCESSING AND MANAGEMENT

Database processing is an important characteristic for CBT. A typical military training program has a formidable record-keeping requirement which may not be adequately recognized. Modern database processing streamlines record-keeping and facilitates training and training management by providing the most relevant data and information as needed. Furthermore, a sound Database Management System (DBMS) establishes a foundation for additional computer-based enhancements for CBT.

The MTIP needs Database Managers who have a sense of ownership for their databases and maintain empathy with the users. This attitude will result in a training program which is robust and responsive to operator inputs and needs. Databases must be rapidly up-dated as change recommendations are approved or new data and procedures become available. MTIP databases should serve as libraries for their respective type of aircraft.

B. DECISION SYSTEMS

CBT can incorporate features of a Decision Support System (DSS). Managers of CBT are required to make decisions regarding CBT and students. Many decisions are routine and well-structured. A DSS; however, lends aid for those training management decisions which are unstructured. All levels of management and many types of decisions are supported by DSS leading to a more conducive training environment for students enrolled in CBT.

MTIP managers need routine structured reports to control the daily operations of the program. A DSS capability would also provide support for resource optimization concerns and future oriented considerations. DSS provide mathematical, operations research and statistical tools to aid managers with these types of unstructured decisions. With this kind of support, managers can maintain a state-of-the-art system by optimizing available resources and choosing the needed hardware, software and training technology which will bring maximum future benefit.

Expert Systems have found limited application to date in CBT. Their potential, however, is very significant. Expert Systems offer the possibility of teaching another dimension of knowledge, namely, heuristics. These systems can help students learn in a classroom from the experience and expertise of others. This can provide students with a level of knowledge which has traditionally not been taught by conventional methods.

The MTIP is an excellent candidate for Expert System-based training. It does not concentrate on topical classroom training; rather, it is action and performance oriented. The MTIP does teach basic facts and procedures, but its major focus is to train students to think and act like successful, experienced aircraft maintenance technicians.

C. MAINTENANCE TRAINING IMPROVEMENT PROGRAM MANAGEMENT

It is apparent that equipment and systems to be maintained by military personnel are becoming more sophisticated and technically advanced. CBT offers the potential to bring substantial computing power to personnel training. For CBT to be effective it must be regarded as a new technology. It is not merely a combination of existing educational and computer technologies. The adequacy and quality of CBT depend on the effort which goes into its planning, design, development and implementation. The various aspects of computing power--database processing and management, decision support and Expert Systems--bring a synergy to CBT which can dramatically improve the training provided.

The primary thrust is that CBT may be more fully applied to the Maintenance Training Improvement Program (MTIP). Both the current MTIP arrangement and future developments and enhancements can benefit greatly from a systematic CBT approach. Considerable work remains to develop CBT technology for MTIP to the level described here. Decision systems for training are in their infancy. Personnel policies must ensure the adequate recruitment and assignment of people to do MTIP development, implementation and maintenance. Sites must be selected to test prototype developments.

Thus, naval aviation maintenance technicians can be better prepared to meet the challenges of an increasingly complex environment where high, sustained equipment and system readiness is expected and required.

APPENDIX A

DEFINITION OF TERMS

There is a proliferation of terminology associated with CBT. The field is made up of people and commercial vendors with very diverse backgrounds. CBT also has a wide variety of applications and considerable variability in the use of terms is found in the literature. Some of the most common terms are listed to explain their meaning and the concepts which the terms represent [Burke 82:pp. 180-181].

DEFINITION OF TERMS

Automated Instruction (AI) Any type of instruction in which administration or delivery is controlled by a computer.

Automated Teaching (AT) See Automated Instruction.

Automated Training (AT) See Automated Instruction.

Computer-Aided (Assisted) Instruction (CAI) An application of Computer-Based Training that involves an on-line interactive learning process where a computer is the primary delivery system.

Computer-Aided (Assisted) Education (CAE) See Computer-Aided Instruction.

Computer-Aided (Assisted) Learning (CAL) See Computer-Aided Instruction.

Computer-Aided (Assisted) Training (CAT) See Computer-Aided Instruction.

Computer-Based Education (CBE) See Computer-Based Training.

Computer-Based Instruction (CBI) See Computer-Based Training.

Computer-Based Training (CBT) An interactive computer training system in which a computer is the primary delivery system and is used to provide overall training management.

Computer-Managed Education (CME) See Computer-Managed Instruction.

Computer-Managed Instruction (CMI) An application of Computer-Based Training which uses a computer to direct students through their training and produces reports on student performance or system utilization. It has elements in common with Computer-Aided Instruction, but Computer-Managed Instruction usually refers to a stand-alone system.

Computer-Managed Learning (CML) See Computer-Managed Instruction.

Computer-Managed Training (CMT) See Computer-Managed Instruction.

Conventional Instruction (CI) Classroom, laboratory or lecture instruction which is presented to a group of students as a whole. Students usually have similar academic aptitudes and all receive the same instruction. Instruction is paced at a rate to accommodate all or nearly all students.

Embedded Computer-based Training Interactive training which is an integral part of equipment or a system.

Individualized Instruction (II) Instruction which accommodates individual differences in aptitude, skill level, prior knowledge and learning style. It is characterized by minimal time constraints, choice of instructional medium and adjustments to the training program as it progresses based on feedback.

Intelligent Computer-Aided Instruction (ICAI) A Computer-Aided Instruction (see) system implemented by Expert System knowledge base techniques.

Programmed Instruction (PI) Instruction in which material is presented cumulatively in small steps and progresses as the student masters each step. It may be presented by either computerized or noncomputerized media.

Self-Paced Instruction (SPI) Instruction which allows students of different aptitudes and prior knowledge to progress through a training program at their own rate.

APPENDIX B

ACRONYMS

There are many acronyms associated with Computer-Based Training (CBT) and computer technology. A military application may introduce unfamiliar acronyms for activities as well as systems or concepts. A reference source is provided to specify and clarify acronyms applicable to military CBT.

ACRONYMS

AFHRL	Air Force Human Resources Laboratory, Brooks Air Force Base, Texas
AIS	Advanced Instructional System
CAI	Computer-Aided Instruction
CBT	Computer-Based Training
CCP	Communication Control Program
CETS	Contractor Engineering Technical Services
CNET	Chief of Naval Education and Training, Pensacola, Florida
CMI	Computer-Managed Instruction
DBMS	Database Management System
DSS	Decision Support System
EDP	Electronic Data Processing
FRAMP	Fleet Readiness/Replacement Aviation Maintenance Personnel
ICAI	Intelligent Computer-Aided Instruction
IDA	Institute for Defense Analysis, Arlington, Virginia
ISD	Instructional Systems Development
KBMS	Knowledge Base Management System
MBMS	Model Base Management System
MIS	Management Information System
MTIP	Maintenance Training Improvement Program
NAMP	Naval Aviation Maintenance Program
NATTC	Naval Air Technical Training Center, Millington, Tennessee

NAVAIR	Naval Air Systems Command, Washington, D. C.
NETS	Navy Engineering Technical Services
NPRDC	Navy Personnel Research and Development Center, San Diego, California
OJT	On-Job-Training
PLATO	Program Logic for Automatic Teaching Operations
SDS	Structured Decision System
SME	Subject Matter Expert
TICCIT	Time Shared Interactive Computer-Controlled Information Television

APPENDIX C

LIST OF RELATED WORKS

The Related Works are categorized as being most applicable to one or more of the following topics:

Computer-Based Training and Education

Database Processing and Management

Decision Support

Expert System and Knowledge Technology

LIST OF RELATED WORKS

Computer-Based Training and Education

Air Force Human Resources Laboratory (AFHRL), Brooks AFB, TX, TP-82-24, Computer Based Maintenance Aids System: Preliminary Development and Evaluation of a Prototype, by Donald L. Thomas, September 1982.

Air Force Human Resources Laboratory (AFHRL), Brooks AFB, TX, TR-70-24, Application of Computers in Educational and Training Systems: A Survey of Computer-Assisted Instructional Centers, by Gerald S. Walker and Edward M. Gardner, December 1970.

Air Force Human Resources Laboratory (AFHRL), Brooks AFB, TX, TR-75-4, Impact of Computer-Based Instruction on Attitudes of Students and Instructors: A Review, by Anne Truscott King, May 1975.

Anderson Ian, "Computer Teaching Methods Need a Rethink," New Scientist, v. 107, p. 34, 5 September 1985.

Ash, Ruth Cranford, An Analysis of the Cost-Effectiveness of a Computer Assisted Instructional Program, Ph.D. Dissertation, Auburn University, Auburn, AL, 1985.

Becker, Henry Jay, "Using Computer for Instruction," BYTE, v. 12, pp. 149-162, February 1987.

Booth, Taylor L., "Computer Education," Computer, v. 17, pp. 57-68, October 1984.

Brudner, Harvey J., "Computer-Managed Instruction," Science, v. 162(3857), pp. 970-976, 29 November 1968.

Buck, John A., "Federal Aviation Administration Seventh Year Computer-Based Training Report," Journal of Computer-Based Instruction, v. 8(3), pp. 53-55, February 1982.

Chief of Naval Education and Training, Pensacola, FL, TAEG Technical Report No. 14, Computer Managed Instruction in Navy Training, by Morris G. Middleton, Clarence J. Papetti and Gene S. Micheli, March 1974.

Chief of Naval Education and Training, Pensacola, FL, TAEG Technical Report No. 44, Computer Managed Instruction at Remote Sites by Satellite: Phase I, A Feasibility Study, by Kenneth A. Polcyn, E. Scott Baudhuin, Henry T. Ingle, Bernard E. Keiser, Bernard H. Rudwick and William E. Woods, December 1976.

Chief of Naval Education and Training, Pensacola, FL, TAEG Technical Report No. 49, Computer Managed Instruction at Remote Sites: Phases II-III, A Demonstration Design, by Kenneth A. Polcyn, E. Scott Baudhuin, Lawrence T. Brekka, Margaret H. Hoyt, Bernard E. Keiser, Della M. Kennelly and Bernard H. Rudwick, December 1977.

Chief of Naval Education and Training, Pensacola, FL, TAEG Technical Report No. 78, An Assessment of Individualized Instruction in Navy Technical Training, by M. Michael Zajkowski, Edward A. Heidt, James M. Corey, Dorothy V. Mew and Gene S. Micheli, November 1979.

Chief of Naval Education and Training, Pensacola, FL, TAEG Technical Report No. 89, Computer Based Instructional Systems...1985 to 1995, by Gene S. Micheli, Charles L. Morris and William M. Swope, August 1980.

Chief of Naval Education and Training, Pensacola, FL, TAEG Technical Report 117, A Comparison of Individualized & Conventional Instruction in Navy Technical Training, by Eugene R. Hall and Jon S. Freda, March 1982.

Chief of Naval Education and Training, Pensacola, FL, TAEG Technical Report 119, Analysis of Factors Affecting the Performance of the Navy's Computer Managed Instructional System, by William M. Swope, James M. Corey, Richard M. Evans and Charles L. Morris, April 1982.

Chief of Naval Education and Training, Pensacola, FL, TAEG Technical Report 141, The Application of Distributed System Architectures for Computer-Based Instructional Systems in the Naval Education and Training Command, by Barney L. Capehart and Charles L. Morris, Jr., February 1983.

Chief of Naval Education and Training, Pensacola, FL, TAEG Technical Report 147, Self-Paced and Conventional Instruction in Navy Training: A Comparison on Elements of Quality, by Richard M. Evans and Richard Braby, July 1983.

Chief of Naval Education and Training, Pensacola, FL, TAEG Technical Report 152, Design, Development, Implementation, and Evaluation of the Computer Aided Interactive Testing System (CAITS), August 1983.

Chorover, Stephan L., "Cautions on Computers in Education," BYTE, v. 9, pp. 223-226, June 1984.

Coffee, Michael B., "Computerized Simulators Offer Quality Training at Modest Cost," Power, edited by Tom Elliott, v. 131, pp. 55-58, January 1987.

Comeau, B. J. (Perry), "Does Your CBT Course Teach Performance?" Training and Development Journal, v. 40(7), July 1986, pp. 42-44.

Eller, Ben F., Kaufman, Alan S., and McLean, James E., "Computer-Based Assessment of Cognitive Abilities: Current Status/Future Directions," Journal of Educational Technology Systems, v. 15(2), pp. 137-147, 1986-87.

Ellis, John A., editor, Military Contributions to Instructional Technology, Praeger Publishers, 1986.

Federico, Pat-Anthony, "Individual Differences in Cognitive Characteristics and Computer-Managed Mastery Learning," Journal of Computer-Based Instruction, v. 9(1), pp. 10-18, Summer 1982.

Federico, Pat-Anthony, "Changes in the Cognitive Components of Achievement as Students Proceed Through Computer-Managed Instruction," Journal of Computer-Based Instruction, v. 9(4), pp. 156-168, Spring 1983.

Furr, Coleman, The Effect of Ungraded Testing on Student Learning in Computer Managed Instruction, Ph.D. Dissertation, United States International University, San Diego, CA, 1982.

Gery, Gloria, Making CBT Happen, Weingarten Publications, Inc., 1987.

Gray, Susan H., "The Effect of Sequence Control on Computer Assisted Learning," Journal of Computer-Based Instruction, v. 14(2), pp. 54-56, Spring 1987.

Halff, Henry M., Hollan, James D., and Hutchins, Edwin L., "Cognitive Science and Military Training," American Psychologist, v. 41(10), pp. 1131-1139, October 1986.

Hassett, James and Dukes, Sheree, "The New Employee Trainer: A Floppy Disk," Psychology Today, v. 20(9), pp. 30-36, September 1986.

Henderson, Peter B., "A Computer-Aided Instructional Environment," Journal of Educational Technology Systems, v. 15(3), pp. 281-301, 1986-87.

Hendrickson, C., Pasquale, A., Robinson, W., and Rossi-Velasco, M., "Applications of Computer Aided Instruction," Journal of Professional Issues in Engineering, v. 112, pp. 194-202, July 1986.

Hillelsohn, Michael J., "How to Think About CBT," Training and Development Journal, v. 38(12), pp. 42-44, December 1984.

Institute for Defense Analysis (IDA), Arlington, VA, Paper P-1568, Cost-Effectiveness of Maintenance Simulators for Military Training, by J. Orlansky and J. String, August 1981.

Kearsley, Greg P., and Hillelsohn, Michael J., "Human Factors Considerations for Computer-Based Training," Journal of Computer-Based Instruction, v. 8(4), pp. 74-84, May 1982.

Kedem, Avi and Smilansky, Jonathan, "Maintenance Training Packages: An Integrated Approach," Training and Development Journal, v. 40(6), pp. 62-65, June 1986.

Kontos, George, "Instructional Computing: In Search of Better Methods for the Production of CAI Lessons," Journal of Educational Technology Systems, v. 13(1), pp. 3-14, 1984-85.

Korbak, Michael, Jr., Computer-Managed Instruction: Theory, Application, and Some Key Implementation Issues, Masters Thesis, Naval Postgraduate School, Monterey, CA, March 1984.

Lahey, George F., "The Effect of Instructional Sequence on Performance in Computer-Based Instruction," Journal of Computer-Based Instruction, v. 7(4), pp. 111-116, May 1981.

Lindahl, Charles E., "Applying Computer Technology to Training Systems," Defense Management Journal, v. 16(4), pp. 38-43, Fourth Quarter 1980.

Medsker, Karen L., and Medsker, Larry R., "Instructional Technology: A Key to Successful Information Systems," Information & Management, v. 12(4), pp. 195-208, April 1987.

Meeks, Brock N., "The Quiet Revolution," BYTE, v. 12, pp. 183-190, February 1987.

Naval Training Systems Center, Orlando, FL, TR 87-003, Individual Differences in Military Training Environments: Four Areas of Research, by Joyce Hogan, Steven Arneson and Eduardo Salas, April 1987.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, SR 83-13, Development of a Computer-Based Tactical Training System, by Alice M. Crawford and James D. Hollan, January 1983.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, SR 83-43, Evaluation of the CMI Instructor Role Training Program in the Navy and Air Force, by Barbara L. McCombs and Jacqueline L. Dobrovolny, June 1983.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TN 87-4, Computer-Based System for Assessing Semantic Knowledge: Enhancements, by Nina L. Liggett and Pat-Anthony Federico, December 1986.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TN 87-25, Characteristics of Navy Training Courses and Potential for Computer Support, by C. Douglas Wetzel, Donald L. Van Kekerix and Wallace H. Wulfeck II, May 1987.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 82-16, Computer-Managed Instruction in the Navy: V. The Effects of Charted Feedback on Rate of Progress Through a CMI Course, by N. H. Van Matre, H. S. Pennypacker, W. H. Hartman, B. E. Brett and L. Q. Ward, November 1981.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 82-19, Computer-Managed Instruction in Navy Technical Training: An Attitudinal Survey, by Carol Ann Robinson, Elizabeth A. Tomblin and Archester Houston, December 1981.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 82-53, An Evaluation of Individualized, Job-Specific Maintenance Training, by Kirk A. Johnson, Linda L. Graham and Stuart B. Carson, July 1982.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 83-31, The Instructional Quality Inventory (IQI): Evaluation Tool for Instructional Systems Development, by William E. Montague, John A. Ellis and Wallace H. Wulfeck II, August 1983.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 84-29, Computer-Based Instruction: Stability of Cognitive Components, by Pat-Anthony Federico, February 1984.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 84-30, Computer-Managed Instruction: Individual Differences in Student Performance, by Pat-Anthony Federico, February 1984.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 85-11, Computer-Based Systems for Navy Classroom Training, by William E. Montague, November 1984.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 87-14, Cognitive Factors in Learning and Retention of Procedural Tasks, by Paula J. Konoske and John A. Ellis, December 1986.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 88-2, Field Evaluation of Simulation for Maintenance Training: SH-3 Helicopter Electro-Mechanical Bladefold System, by V. M. Malec and M. Luszczak, October 1987.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 88-3, Analysis of Navy Technical School Training Objectives for Microcomputer Based Training Systems, by C. Douglas Wetzel, Donald L. Van Kekerix and Wallace H. Wulfeck II, October 1987.

O'Neil, Harold F. Jr., editor, Computer-Based Instruction, Academic Press, Inc., 1981.

Orlansky, Jesse and String, Joseph, "Computer-Based Instruction for Military Training," Defense Management Journal, v. 17(2), pp. 46-54, Second Quarter 1981.

Pressman, Israel and Rosenbloom, Bruce, "CAI: Its Cost and Its Role," Journal of Educational Technology Systems, v. 12(3), pp. 183-208, 1983-84.

Rockart, John Fralick and Scott Morton, Michael S., Computers and the Learning Process in Higher Education, McGraw-Hill Book Company, 1975.

Sassone, Peter G., "The Economic Evaluation of Military Training Programs," Defense Management Journal, v. 18(4), pp. 39-42, Fourth Quarter 1982.

Steinberg, Esther R., Teaching Computers to Teach, Lawrence Erlbaum Associates, Inc., 1984.

Database Processing and Management

Date, C. J., An Introduction to Database Systems, Volume II, Addison-Wesley Publishing Company, 1983.

Katzan, Harry, Jr., Computer Data Management and Data Base Technology, Van Nostrand Reinhold Company, 1975.

House, William C., editor, Interactive Decision Oriented Data Base Systems, Mason/Charter Publishers, Inc., 1977.

Scott Morton, Michael S., Management Decision Systems, Harvard University, 1971.

Decision Support

Ginzberg, Michael J., Reitman, Walter and Stohr, Edward A., editors, Decision Support Systems, Proceedings of the NYU Symposium on Decision Support Systems, 21-22 May 1981, North-Holland Publishing Company, 1982.

House, William C., editor, Interactive Decision Oriented Data Base Systems, Mason/Charter Publishers, Inc., 1977.

Hughes, Cary T., "Relationships Between Demographics, Training, etc. in a DSS Environment," Information & Management, v. 12(5), pp. 257-261, May 1987.

Mittra, Sitansu S., Decision Support Systems, John Wiley & Sons, Inc., 1986.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TN 87-4, Computer-Based System for Assessing Semantic Knowledge: Enhancements, by Nina L. Liggett and Pat-Anthony Federico, December 1986.

Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 87-14, Cognitive Factors in Learning and Retention of Procedural Tasks, by Paula J. Konoske and John A. Ellis, December 1986.

Sprague, Ralph H., Jr., and Watson, Hugh J., editors, Decision Support Systems, Prentice-Hall, 1986.

Scott Morton, Michael S., Management Decision Systems, Harvard University, 1971.

Seidel, Robert J., and Weddle, Peter W., editors, Computer-Based Instruction in Military Environment, Plenum Press, 1987.

"Artificially-Intelligent Maintenance Diagnostics," Simulation, v. 48(2), pp. 74-75, February 1987.

Brodie, Michael L. and Mylopoulos, John, editors, On Knowledge Base Management Systems, Springer-Verlag, Inc., 1986.

Clancey, William J., Knowledge-Based Tutoring: The GUIDON Program, The MIT Press, 1987.

Harris, Steven D., and Owens, Jerry M., "Some Critical Factors That Limit the Effectiveness of Machine Intelligence Technology in Military Systems Applications," Journal of Computer-Based Instruction, v. 13(2), pp. 30-34, Spring 1986.

Institute of Cognitive Science, University of Colorado, Boulder, CO, Technical Report No. 142, A Multimedia Knowledge Representation for an "Intelligent" Computerized Tutor, by Patricia Baggett and Andrzej Ehrenfeucht, April 1985.

Pipitone, Frank, "An Expert System for Electronics Troubleshooting Based on Qualitative Causal Reasoning," Journal of Computer-Based Instruction, v. 13(2), Spring 1986, pp. 39-42.

Seidel, Robert J., and Weddle, Peter W., editors, Computer-Based Instruction in Military Environment, Plenum Press, 1987.

Sleeman, D., and Brown, J. S., editors, Intelligent Tutoring Systems, Academic Press, Inc., 1982.

U. S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA, Research Report 1412, Smart Technology for Training: Promise and Current Status, by Wayne D. Gray, Daniel B. Pliske and Joseph Psotka, March 1985.

University of Pittsburgh Technical Report No. LSP-3, Pittsburgh, PA, An Object-Oriented Architecture for Intelligent Tutoring Systems, by Jeffrey Bonar, Robert Cunningham and Jamie Schulz, 14 August 1987.

REFERENCES

[Baker 81] Baker, Frank, "Computer-Managed Instruction: A Context for Computer-Based Instruction," Computer-Based Instruction, edited by Harold F. O'Neil, Jr., Academic Press, Inc., 1981.

[Bevan 87] Bevan, S. J., and Wetherall, P. R., "The Conversion of an Expert System to an Intelligent CAI System," Computer-Based Instruction in Military Environments, edited by Robert J. Seidel and Peter D. Weddle, Plenum Press, 1987.

[Bork 87] Bork, Alfred, "The Potential for Interactive Technology," BYTE, v. 12, February 1987.

[Bryant 88] Bryant, Robert A., "An 'Intelligent' Interface to CBT," Journal of Educational Technology Systems, v. 16(3), 1987-88.

[Burke 82] Burke, Robert L., CAI Sourcebook, Prentice-Hall, 1982.

[Cesena 87] Cesena, Mary L., and Jones, Wendell O., "Accelerated Information Systems Development in the Army," Spectrum, v. 4(3), September 1987.

[Clancey 87] Clancey, William J., Knowledge-Based Tutoring: The GUIDON Program, The MIT Press, 1987.

[CNAP 86] Commander, Naval Air Force, United States Pacific Fleet (COMNAVAIRPAC), San Diego, CA, Instruction 1543.1, April 18, 1986.

[Date 86] Date, C. J., An Introduction to Database Systems, Fourth edition, Volume I, Addison-Wesley Publishing Company, 1986.

[Davis 83] Davis, William S., Systems Analysis and Design, Addison-Wesley Publishing Company, 1983.

[Dean 83] Dean, Christopher and Whitlock, Quentin, A Handbook of Computer-Based Training, Nichols Publishing Company, 1983.

[Fletcher 86] Fletcher, J. Dexter and Rockway, Marty R., "Computer-Based Training in the Military," Military Contributions to Instructional Technology, edited by John A. Ellis, Praeger Publishers, 1986.

[Gorry 71] Gorry, G. Anthony and Scott Morton, Michael S., "A Framework for Management Information Systems," Sloan Management Review, v. 13(1), Fall 1971.

[Hansen 75] Hansen, Duncan N., Ross, Steven M., Bowman, Harry L., and Thurmond, Paul, Navy Computer Managed Instruction: Past, Present, and Future, Memphis State University, Memphis, TN, Bureau of Educational Research and Services, 1975.

[Harmon 85] Harmon, Paul and King, David, Expert Systems, John Wiley & Sons, Inc., 1985.

[Head 67] Head, Robert V., "Management Information Systems: A Critical Appraisal," Datamation, v. 13(5), May 1967.

[IDA P-1375, 79] Institute for Defense Analysis (IDA), Arlington, VA, Paper P-1375, Cost-Effectiveness of Computer-Based Instruction in Military Training, by Jesse Orlansky and Joseph String, April 1979.

[Kearsley 83] Kearsley, Greg, Computer-Based Training, Addison-Wesley Publishing Company, Inc., 1983.

[Kearsley 84] Kearsley, Greg, Training and Technology, Addison-Wesley Publishing Company, Inc., 1984.

[Kearsley 85] Kearsley, Greg and Seidel, Robert J., "Automation in Training and Education," Human Factors, v. 27(1), 1985.

[Kontos 84] Kontos, George, "Instructional Computing: In Search of Better Methods for the Production of CAI Lessons," Journal of Educational Technology Systems, v. 13(1), 1984-85.

[Kroenke 83] Kroenke, David M., DATABASE PROCESSING: Fundamentals, Design, Implementation, Second edition, Science Research Associates, Inc., 1983.

[Kroenke 87] Kroenke, David M., and Dolan, Kathleen A., Business Computer Systems, Third edition, Mitchell Publications, Inc., 1987.

[Logan 82] Logan, Robert S., Instructional Systems Development, Academic Press, Inc., 1982.

[Lynch 71] Lynch, Robert Michael, A Cost Effectiveness Analysis of Computer Assisted Instruction, Ph.D. Dissertation, University of Northern Colorado, Greeley, CO, Winter 1971.

[Mason 69] Mason, Richard O., "Basic Concepts for Designing Management Information Systems," 1969, reprinted in Measurement for Management Decision, Addison-Wesley, 1981.

[Mylopoulos 86] Mylopoulos, John, "On Knowledge Base Management Systems," On Knowledge Base Management Systems, edited by Michael L. Brodie and John Mylopoulos, Springer-Verlag, Inc., 1986.

[NAMP 86] Chief of Naval Operations (OPNAV), Washington, D. C., Instruction 4790.2D, October 1, 1986.

[NPRDC TN 82-17, 82] Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TN 82-17, Computer-Based Education and Training Functions: A Summary, by R. D. Peters, May 1982.

[NPRDC TR 82-45, 82] Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 82-45, Instructor's Role in Individualized Training: A Survey of Two Computer-Managed Courses, by Kirk A. Johnson and Linda L. Graham, May 1982.

[NPRDC TR 84-54, 84] Navy Personnel Research and Development Center (NPRDC), San Diego, CA, TR 84-54, Computer-Based Instruction: Will It Improve Instructional Quality?, by William E. Montague and Wallace H. Wulfeck II, August 1984, reprinted from Training Technology Today, v. 1(2), pp. 4-19, Winter 1984.

[O'Neil 81] O'Neil, Harold F., Jr., and Paris, Judith, "Introduction and Overview of Computer-Based Instruction," Computer-Based Instruction, edited by Harold F. O'Neil, Jr., Academic Press, 1981.

[Parkinson 57] Parkinson, C. Northcote, Parkinson's Law, Houghton Mifflin Company, 1957.

[Richardson 86] Richardson, J. Jeffrey and Jackson, Terresa E., "Developing the Technology for Intelligent Maintenance Advisors," Journal of Computer-Based Instruction, v. 13(2), Spring 1986.

[Ruck 86] Ruck, Hendrick W., and Lang, John W., "Training-Decision Systems," Military Contributions to Instructional Technology, edited by John A. Ellis, Praeger Publishers, 1986.

[Seidel 81] Seidel, Robert J., and Wagner, Harold, "Management," Computer-Based Instruction, edited by Harold F. O'Neil, Jr., Academic Press, 1981.

[Spiro 87] Spiro, R. J., "Experience-Consolidation Systems: A Sketch of a Theory of Computer-Based Instruction in Ill-Structured Domains," Computer-Based Instruction in Military Environments, edited by Robert J. Seidel and Peter D. Weddle, Plenum Press, 1987.

[Sprague 77] Sprague, Ralph H., Jr., and Watson, Hugh J., "MIS Concepts Part 1," Interactive Decision Oriented Data Base Systems, edited by William C. House, Petrocelli/Charter, 1977, reprinted from Journal of Systems Management, pp. 34-37, January 1975.

[Sprague 80] Sprague, Ralph H., Jr., "A Framework for the Development of Decision Support Systems," MIS Quarterly, 4(4), June 1980, reprinted in Decision Support Systems, edited by Ralph H. Sprague, Jr., and Hugh J. Watson, Prentice-Hall, 1986.

[Sprague 82] Sprague, Ralph H., Jr., and Carlson, Eric D., Building Effective Decision Support Systems, Prentice-Hall, 1982.

[Turban 85] Turban, Efraim and Watkins, Paul R., "Integrating Expert Systems and Decision Support Systems," Transactions of the Fifth International Conference on DSS (DSS '85), reprinted in Decision Support Systems, edited by Ralph H. Sprague, Jr., and Hugh J. Watson, Prentice-Hall, 1986.

[Wiederhold 86] Wiederhold, Gio, "Knowledge versus Data," On Knowledge Base Management Systems, edited by Michael L. Brodie and John Mylopoulos, Springer-Verlag, Inc., 1986.

INITIAL DISTRIBUTION LIST

1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22304-6145	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93943-5002	2
3.	Director, Information Systems (OP-945) Office of the Chief of Naval Operations Navy Department Wahington, D. C. 20350-2000	1
4.	Curricular Office, Code 37 Computer Technology Naval Postgraduate School Monterey, California 93943	1
5.	Deputy Chief of Naval Operations (Air Warfare) Navy Department Washington, D. C. 20360-5100	1
6.	Commander, Naval Air Force U. S. Pacific Fleet Naval Air Station, North Island San Diego, California 92135	1
7.	Commander, Naval Air Force U. S. Atlantic Fleet Norfolk, Virginia 23511	1
8.	Major John B. Isett Code 54IS Naval Postgraduate School Monterey, California 93943	1
9.	Lieutenant Colonel Gerald L. Pauler Code 55PA Naval Postgraduate School Monterey, California 93943	1
10.	Lieutenant Commander Galen J. Ledeboer USS Coral Sea (CV 43) FPO New York, New York 09550-2720	5